An Interim Report of the Preliminary Consolidation Test Results on Slurry Type Dredged Soils Following the Modified One-Dimensional Oedometer Test

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Summary

Several ongoing and completed coastal protection and restoration strategies involve marsh creations in the open coastal area by hydraulically dredging riverine sediments and pumping via pipeline for transportation and reducing tidal exchange in marshes. Rates of settlement of fine-grained dredged soils are routinely monitored and predicted. Laboratory consolidation test is an important tool to characterize the settlement of the marsh soils. In this research, two enhancing methods are recommended so that the conventional oedometer and other laboratory test equipment can be fully utilized to conduct the lab consolidation tests.

Dredged soils are highly moisturized and very soft, and thus form a large strain deformation. For this reason, the seating load at the initial consolidation test stage is an essential factor for the consolidation test of slurry-type dredged soils. The conventional oedometer comes up with a seating pressure of 0.01 TSF, including weight of the dial cap and the porous stone, which could ensure a success of testing soil samples with a moisture content up to 70% for the dredged soils. Utilizing 3D printing technology, the dial cap was printed out using the material of Polylactic Acid (PLA). It has turned out that the newly achieved seating pressure has been significantly reduced down to 0.002 TSF, including the porous stone weight. With the 3D-printed dial cap, dredged soil samples with a moisture content up to100% could be successfully tested.

Among the two enhancing methods, Method One recommended in this research is a quick method utilizing the oven-dry way to lower the initial moisture content of slurry samples for a possible conventional oedometer consolidation test. Method Two refers to the combination of a small-scale settling column /self-weight consolidation test and the modified oedometer test. Intermediate results obtained so far have manifested a great success of the consolidation tests for a slurry sample having a water content up to 210% with a wide spectrum of void ratio vs. effective stress plotted, mimicking the in-situ self-weight consolidation condition at the marsh creation sites.

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Introduction

Two methods are adopted to conduct consolidation tests of slurry type dredged soils based on EM 1110-2-1906 (Army 1970), EM 1110-2-5027 (Army 1987), ASTM D-2435 (ASTM 1996), CPRA Geotechnical Standards (CPRA 2017), the ocean drilling program's recommended test method (Texas A&M University 2007), and the method proposed by Azimi (2018). Both of the test methods are adopted such that the conventional oedometer and available laboratory test equipment can be fully utilized. The research aims to determine the most applicable and reliable test procedure to obtain more accurate consolidation properties. In this interim report, preliminary test results were presented following the two methods, which were described in details in the research plan.

Slurry preparation

The slurry soil samples were prepared using the bored soil samples from the No-Name Bayou marsh creation site, which reflects the natural condition of dredged soil. Four buckets of dredged soil samples were shipped in from Ardaman and Associates in December 2020. The soils were oven-dried first for 24 hours as seen in Figure 1(a), and then they were crushed using a grinding machine. After water was added to the ground dry soil to make up a slurry sample with an expected moisture content, the wet soil sample was moved to a mixer cup as shown Figure 1(b) for mixing up for about two minutes until it became homogenous slurry. The prepared slurry sample was shown in Figure 1(c).

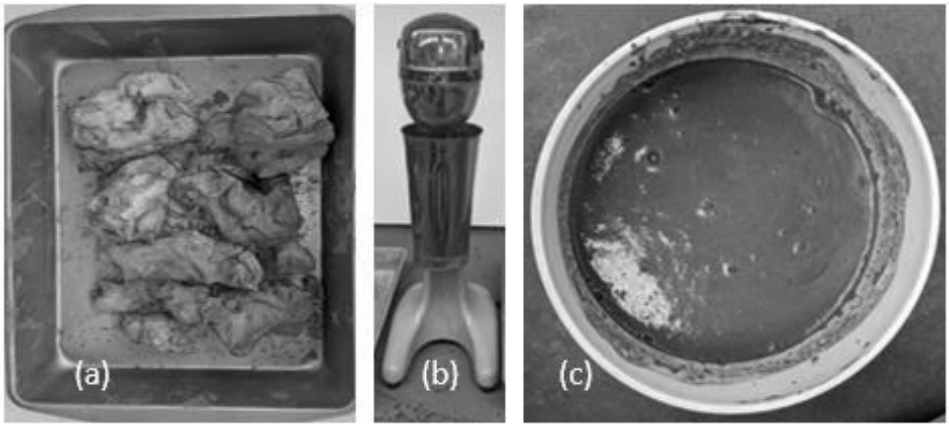


Figure 1. (a) Oven dried soil sample (b) Mixing grinder (c) Prepared slurry soil sample for laboratory consolidation test.

Prior to soil slurry samples were prepared for consolidation tests, fundamental tests were conducted for the Atterberg limits and grain size distribution curves. They were summarized in Appendix A. Figure 16, and 17 in Appendix A presented the Atterberg limits and grain size distributions, respectively. Two slurry samples were prepared, one with a moisture content of 120%, and the other one with 210%, for conducting consolidation tests following Methods One

and Two, respectively. For detailed testing procedures of Methods One and Two, please refer to the research plan we submitted in March 2021.

Intermediate Results from Method One

The slurry sample with a moisture content of 120% was used to perform consolidation tests following Method one. The slurry sample was placed on the tray as shown Figure 2 and put in oven to reduce its moisture content. Maintaining a temperature of 212°F and moving soil samples out of oven every hour for ~5 min to get it stirred up and let it cool down (Texas A&M University 2007). This stirring and cooling process ensures that the soil sample is not thoroughly dried but only thickened. Once the slurry became thickened, it was ready for consolidation test using a conventional oedometer. Conventional 1-D consolidation test results for three slurry samples with water contents equal to 60%, 50%, and 40%, respectively, were presented in this interim report.

Figure 2. Moisture content of the slurry sample decreased by oven drying.

Once the slurry samples became thickened with their initial moisture content reduced to different levels, it is ready for consolidation tests using a conventional oedometer. It is essential to keep a suitable moisture content for the thickened slurry sample in a range between 40% to 60 %, depending upon soil type (Kondo and Torrance 2005), before it was moved to the consolidometers for consolidation test, research was conducted at this stage for various slurry samples with different moisture contents to obtain an optimum moisture content or a most suitable range of moisture contents for slurry consolidation tests. Preliminary test results showed that, if the initial moisture content was greater than around 60%, a tiny portion of soil particles moved out of the consolidometer after a certain amount of load was applied.

Various slurry samples with different moisture contents were placed in the consolidometers (2.5-inch in diameter, 1 inch in height), and they got tested immediately after the samples are moved out of oven. The slurry sample must be slowly scooped into the consolidation rings to prevent the formation of air pockets and voids. Then the tests were conducted following EM 1110-2-5027 and ASTM D-2435 standard. Finding out a proper seating load is one of the significant concerns that could vary depending on the initial moisture content of the thickened slurry sample. In this stage

of the research, 0.01 TSF load was used initially as the seating load or starting load including the load of the top porous stone, stainless steel dial cap, and dial gage force. A load increment ratio of 1 and the loading schedule recommended by ASTM D-2435 is most unlikely to follow for the very soft dredged soils. Studies have been conducted on the EM 1110-2-5027 recommended loading schedule: 0.005, 0.01, 0.025, 0.05, 0.10, 0.25, 0.50, and 1.00 TSF.

Following ASTM D-2435 standard, consolidation settlement readings were taken at the times of 0.1, 0.2, 0.5, 1.0, 2.0, 4.0, 8.0, 15.0, and 30.0 minutes; 1, 2, 4, 8, and 24 hours, and then a load increment will be added. Additional studies would be conducted to see how many more readings must be taken daily after the 24-hour readings until the primary consolidation is completed by analyzing the plotted time-consolidation curves for different consolidation pressures. During the tests, it has been observed that more than 90 percent of the consolidation was done after 24 hours elapsed.

Thickened slurry samples with a moisture content of 60%, 50%, or 40% were successfully tested by following the procedures of a traditional oedometer consolidation test. The seating load is 0.01 TSF, combining the weight of the stainless-steel dial-cap, the porous stone, and the dial gage force for the conventional oedometer. Subjected to the seating load of 0.01 TSF, a slurry sample with a water content greater than 70% could not be run through, because a portion of slurry sample moved out of the consolidometer as soon as the seating load was applied. The plots of effective pressure versus void ratio and effective pressure versus coefficient of consolidation of the slurry samples containing moisture contents of 60%, 50%, and 40% are shown respectively from Figures 3 through 8. Detailed calculations of the effective pressure, void ratio, and coefficient of consolidation of these three tests are presented respectively from Tables 1 through 3 in Appendix A. The permeabilities of the soil slurry samples of each consolidation tests were calculated and presented from Tables 8 through 10 in Appendix A. The plotting for determinations of T_{90} and T_{50} of these tests are presented in Figures 18 through 23, respectively in Appendix B.

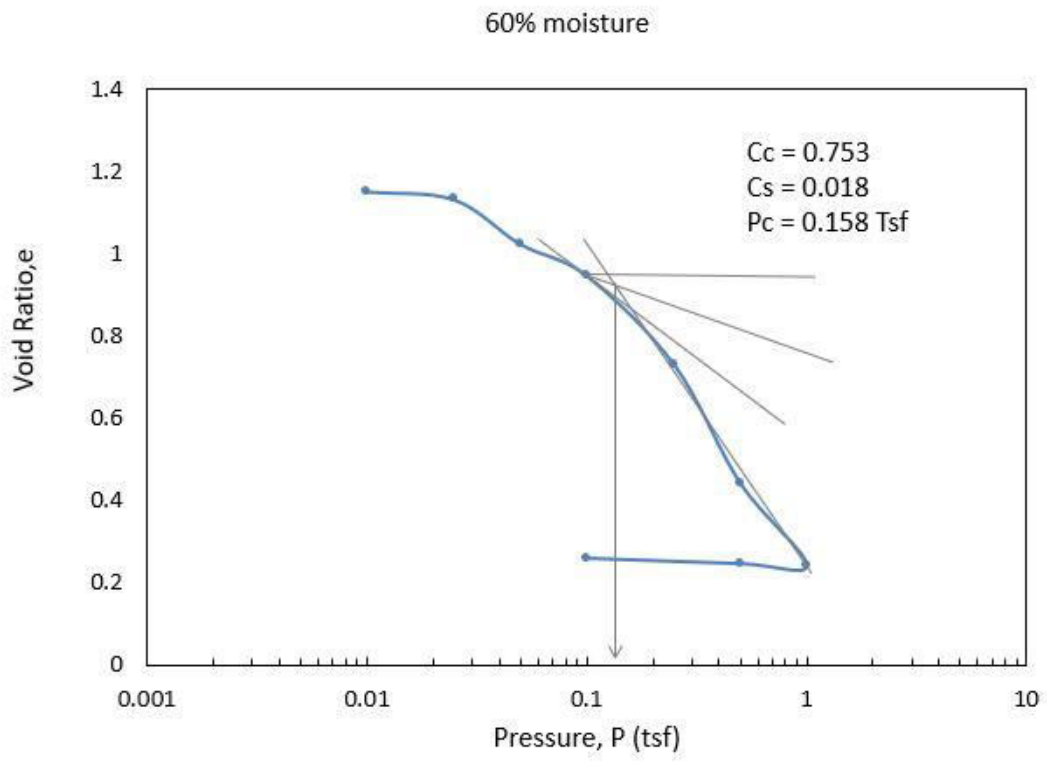


Figure 3. Pressure vs void ratio of the soil sample with an initial water content of 60%

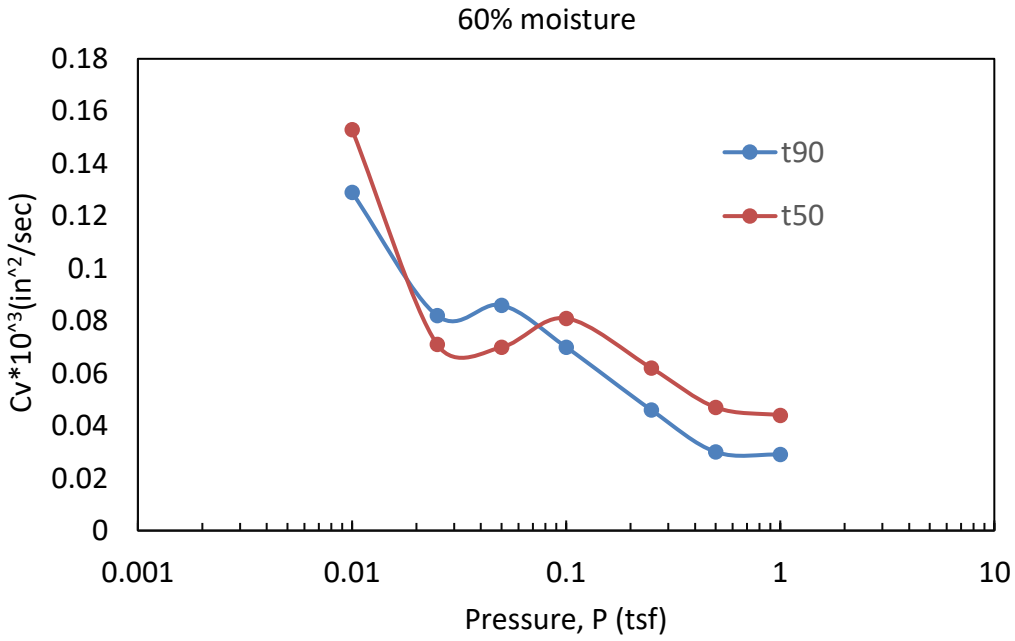


Figure 4. Pressure vs coefficient of consolidation for the soil sample with an initial water content of 60%

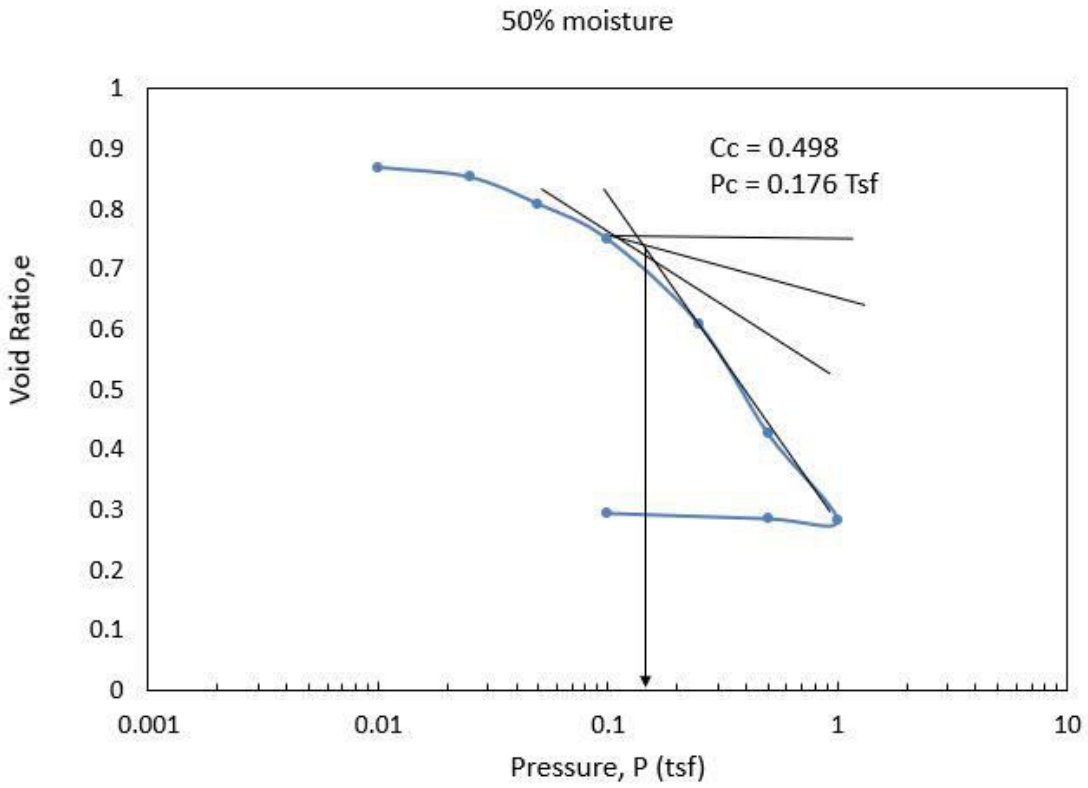


Figure 5. Pressure vs void ratio of the soil sample with an initial water content of 50%

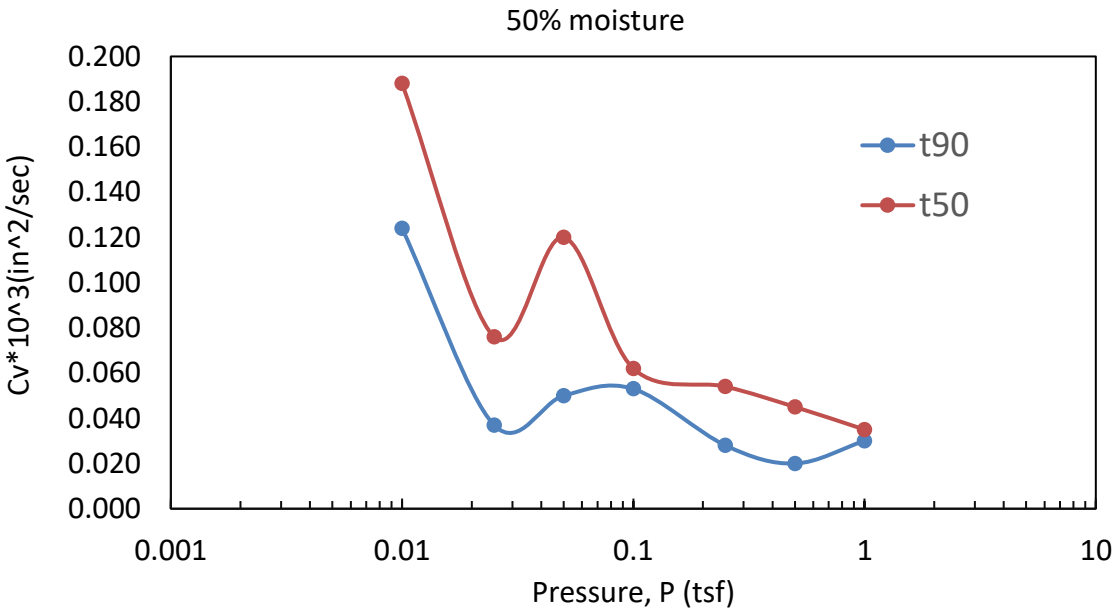


Figure 6. Pressure vs coefficient of consolidation for the soil sample with an initial water content of 50%

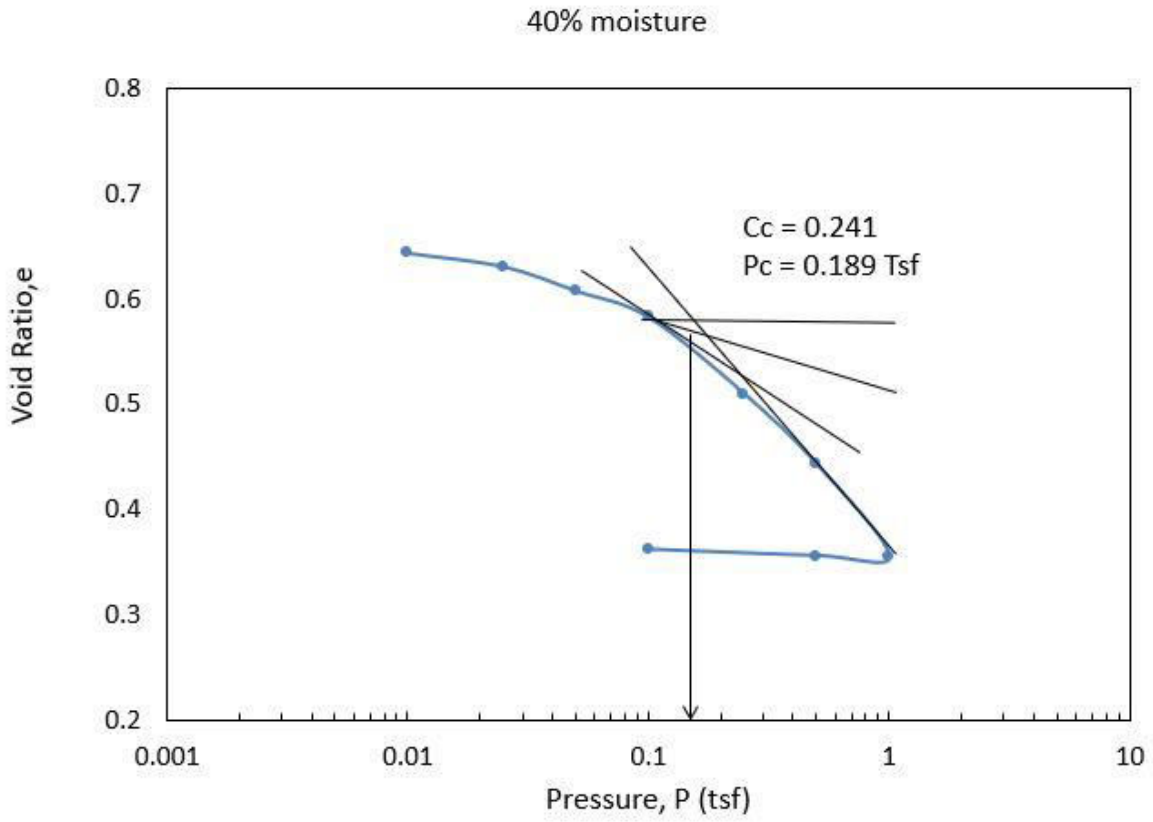


Figure 7. Pressure vs void ratio of the soil sample with an initial water content of 40%

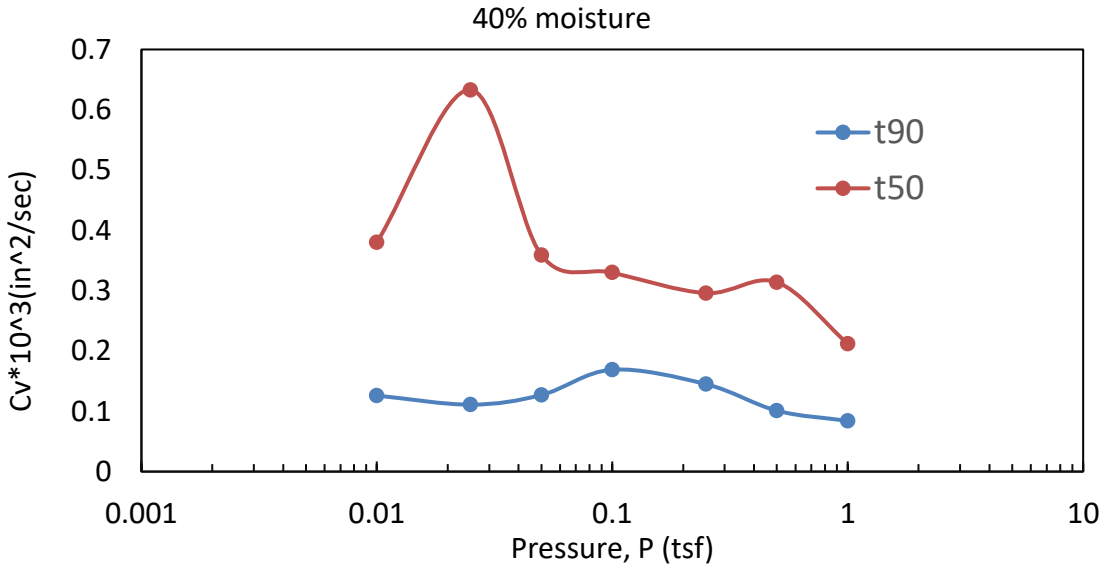


Figure 8. Pressure vs coefficient of consolidation for the soil sample with an initial water content of 40%

Intermediate Results from Method Two

Following the research proposal approved, we focused our research attention on how to modify the conventional 1-D consolidation test. As the first modification, the small-scale settling column test is used to handle those slurry samples with high moisture contents (>=70%). For a slurry sample with a water content greater than 70%, after it was moved in the 1-D consolidometer, as soon as the conventional stainless-steel dial-cap was put on, which was equivalent to the 0.01 TSF initial (sitting) pressure, a portion of the soil specimen would be squeezed out. Thus, the consolidation behavior of the slurry couldn't be achieved with the conventional 1-D consolidation test. For this reason, a small-scale settling column test (self-gravity test) was designed as part of the consolidation test combination. The small-scale settling column test and 1-D consolidation test were combined to handle slurry samples with a water content greater than 70% to find out the void ratio vs. effective stress plots for wide ranges of magnitudes of void ratios and effective stresses.

A suitable time duration for the completion of the settling column test was identified through this research. At the end of each self-weight consolidation test, the moisture content and void ratio were measured and calculated to find out an appropriate duration of the self-weight consolidation test. Data obtained from the self-weight consolidation tests were combined with oedometer tests to estimate the relationships for a wide range of void ratio vs. effective stresses, and some of the plots were presented in this report.

The small-scale settling column tests

The self-weight settling column consolidation test was conducted before the conventional 1-D consolidometer tests started. Once a soil slurry sample was prepared with a pre-designed initial moisture content, unlike those samples that were placed in an oven, it was moved in a settling cylinder for self-weight consolidation test before it was moved to the consolidometer (Scott et al. 1986). In this research, three different diameters of acrylic plexiglass cylinders were utilized with the same height as 10 inches. Those cylinders were six, eight, and 10 inches in inner diameters, respectively. A measuring tape marked into the scale of millimeter was attached to the side of each settling cylinder to take the settlement readings (location of the interface of water/top surface of settled soils). Empty cylinders were weighed before testing to readily calculate the slurry's net weight at the end of each test. The cylinders were filled with slurry approximately to a depth of eight inches. Figure 9 below shows the on-going settling column tests.

As soon as a testing cylinder with the prepared slurry sample was set, the self-weight settling column test started up, with only periodic measurements performed to locate the water/slurry interface. Readings were taken at 0, 0.5, 1, 2, 4, 8, 15, 30, 60, 120, 240 minutes, and then twice daily after that (Azimi et al. 2020). Observations were also made on the slurry's consistency, cloudiness of the expelled water, and any signs of flocculation in the slurry. Generally, it may take 4 to 6 weeks to complete one self-weight settling column test (Lin 1983; Azimi et al. 2020).

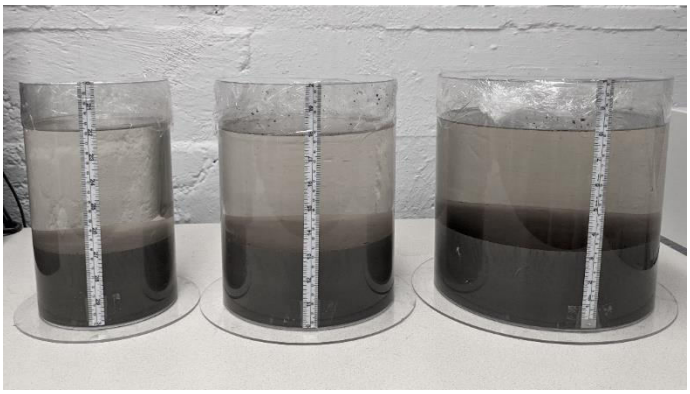


Figure 9. The self-weight consolidation/settling column tests using acrylic plexiglass cylinders with diameters 10″, 8″, and 6″ (Right to left).

Effects of the cylinder diameter, i. e., the effects of the friction between the cylinder wall and slurry soils were studied on the self-weight consolidation settlement (Gao et al. 2016). Once the self-weight consolidation test was completed, the free water was gradually poured out, and amount of free water is measured. Then, the settled soils were ready for the oedometer consolidation tests. If approximately no settlement was observed for one week, it may consider the accomplishment of the self-weight settling column test. The settlement vs. time plot could specify the first part of the primary consolidation curve. In the completed settling column/self-weight consolidation tests, a slurry sample with a water content of 210% was prepared. Three acrylic plexiglass cylinders, as shown in Figure 9 with diameters 10″, 8″, and 6″ were used to find out an acceptable minimum cylinder diameter for the settling column test, in which the effect of friction between slurry and cylinder wall is negligible.

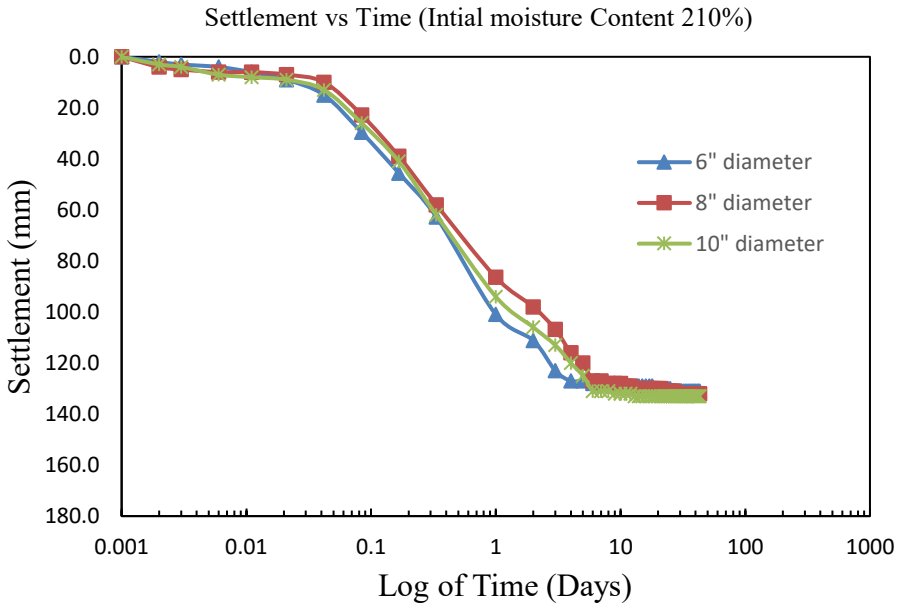


Figure 10. Settlement vs time of settling column tests for cylinders with different diameters.

After reviewing the results, no significant differences were identified on the locations of the interfaces of water/top of settled slurry soils among the three settling column tests. The interface location from the initial top surface of the slurry was interpreted as the slurry settlement. Readings were taken at 0, 0.5, 1, 2, 4, 8, 15, 30, 60, 120, 240 minutes, and then twice daily after that (Azimi et al. 2020). It took almost 24 days to complete the settling column tests. The settlement vs. time relationship was plotted for each cylinder and presented in Figure 10. Those plots did not show significant differences, which strongly suggested that a cylinder with a diameter equal to or greater than six inches should be workable for the settling column tests. Thus, it may be recommended that an acrylic plexiglass cylinder with a diameter of six inches or greater could be used for the settling column test. The effective pressure and void ratio of each settling column test calculated following the method proposed by Azimi et al. (2020). Detailed calculations of effective pressure and void ratio of each settling column test were presented respectively from Tables 4 to 6 in Appendix A. The plot of effective pressure versus void ratio of settling column tests were presented in Figure 11. The permeabilities of the soil slurry samples in the settling column tests were calculated and presented from Tables 11 to 13 in Appendix A.

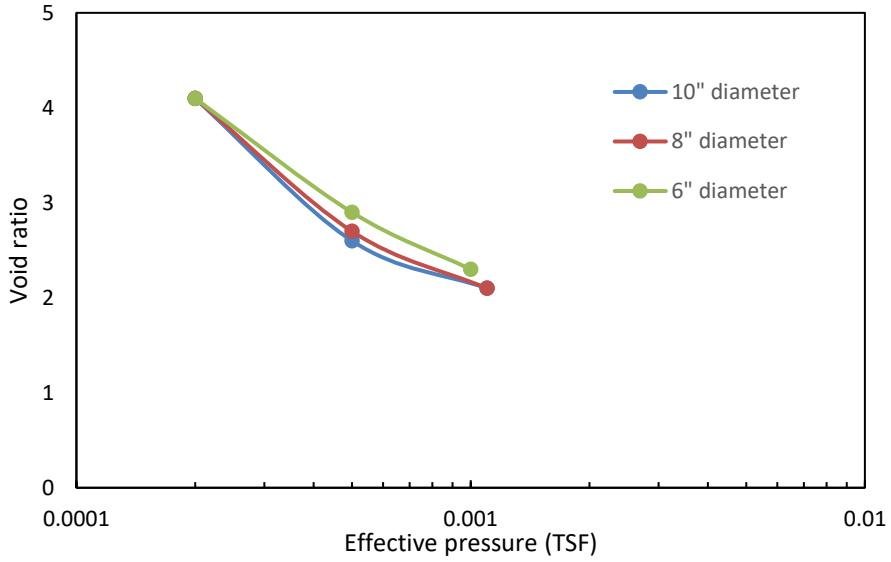


Figure 11. Effective pressure vs void ratio of the three settling column tests.

The 1-D consolidation test using a modified oedometer

After completing the settling column tests, the settled slurry soils were sampled from different depths in the settling columns for the oedometer consolidation tests. As described in the beginning, in order to reduce the seating pressure from the stainless-steel dial-cap in any conventional consolidation test, 3-D printing technology was applied to make up an identical dial-cap with exactly the same shape and sizes but a much lighter weight. Instead of using regular steel material, a special alloy called Polylactic Acid (PLA) was employed. As presented in Figure 12, the 3D-printed dial cap weighs only 20.2 gram while the conventional stainless-steel dial-cap weighs 387.5 gram.

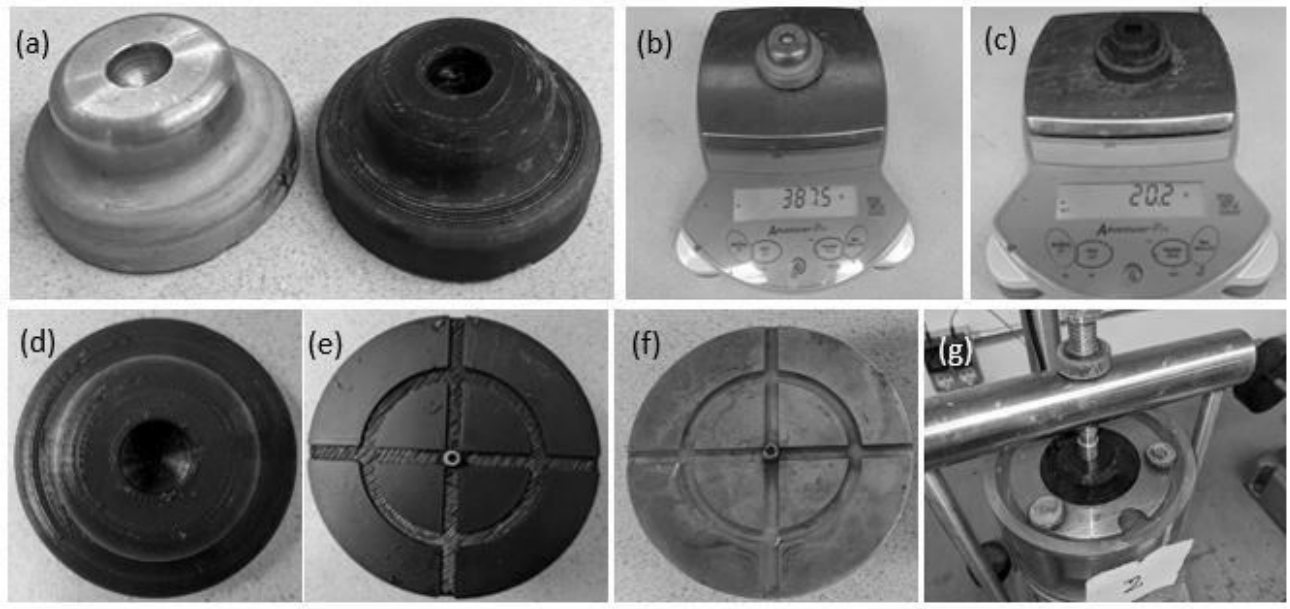


Figure 12. (a) Stainless steel dial cap (on left) and 3D printed polylactic acid (PLA) dial cap (on right), (b) Stainless-steel dial cap with a weigh of 387.5 grams, (c) 3D printed dial cap with a weigh of 20.2 grams, (d) Top view of the 3D-printed dial cap (e) Bottom view of the 3D-printed dial cap (f) Bottom view of the stainless-steel dial cap (g) Consolidation test in-progress using the 3D-printed dial cap.

It turned out that the newly achieved seating pressure was about 0.002 TSF, including the pressure that comes up from the weight of the porous stone, as opposed to the traditional 0.01 TSF. From the preliminary results obtained following Method one, the maximum water content of the slurry soil sample were not able to go beyond 70% if the conventional stainless steel dial cap was used. However, if the 3D-printed dial cap was used, the maximum water content of the slurry samples could go up to as high as 100%. After the slurry soil sample with a water content of 100% was tested successfully using this 3D-printed dial cap, it was observed that at the end of consolidation test with the pressure of 2 TSF, the final settlement of the specimen was greater than 50% of its initial height, which indicated that a large strain deformation occurred in the consolidation test. During the successful consolidation test, the following loading schedule was adopted: 0.002, 0.005, 0.01, 0.025, 0.05, 0.10, 0.25, 0.50, and 1.00 TSF.

The 1-D consolidation tests were completed following ASTM D-2435 standard and EM 1110-2-5027 Appendix D. Consolidation settlement readings were taken at the times 0.1, 0.2, 0.5, 1.0, 2.0, 4.0, 8.0, 15.0, and 30.0 minutes: 1, 2, 4, 8, and 24 hours. At the time of 24 hours, more than 90% of primary consolidation was completed for most of the applied load mentioned above. However, the completion of consolidation might take more than 24 hours if the slurry sample was only subjected to the seating load.

The detailed calculations of effective pressure, void ratio, and coefficient of consolidation of the slurry sample having a moisture content 100.1 % were presented in Table 7 in Appendix A. The

plots of effective pressure versus void ratio and effective pressure versus coefficient of consolidation of the test were shown below in Figures 13 and 14, respectively. The permeabilities of the soil sample in this test was calculated and presented in Table 14 in appendix A. The plots for determination of T_{90} and T_{50} in this test were presented in Figures from 24 through 25 in Appendix B. Other 1-D consolidometer test results with a conventional stainless steel dial cap will be presented in the final master's thesis.

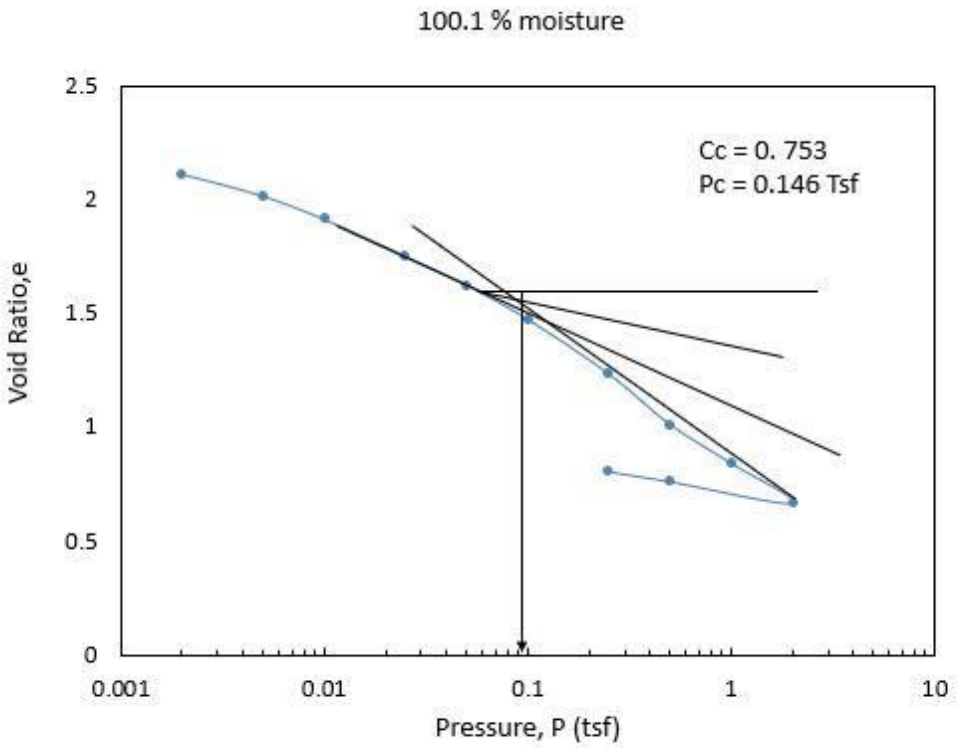


Figure 13. Pressure vs void ratio of the soil sample with an initial water content of 100.1%

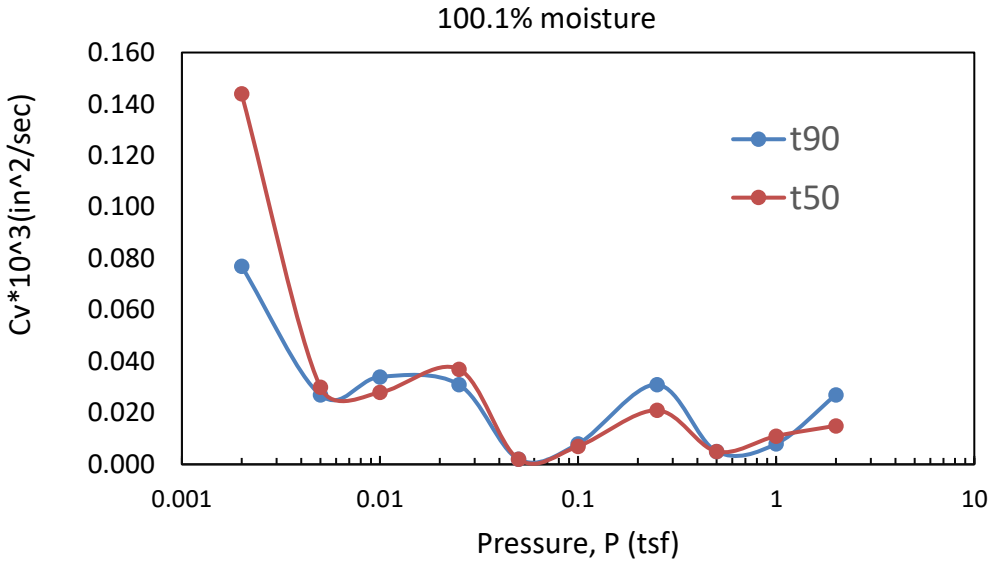


Figure 14. Pressure vs coefficient of consolidation for the soil sample with an initial water content of 100.1%

As described in the beginning of the report, consolidation results from both the settling column test and the 1-D consolidometer test were combined. The void ratio variations from the two tests were plotted against the effective stresses applied. Averaged void ratios were utilized from those obtained from the three settling column tests with the initial moisture content of 210%, and then they were combined to the consolidometer test results with consolidated slurry samples with the initial water of 100.1% from the settling column tests. As an example, the plot of void ratio vs. effective pressure for the slurry sample with an initial water content of 210% was presented in Figure 15. The curve plotted has covered a consolidation pressure ranging from 0.0002 TSF to 2 TSF. The void ratio decreased from the initial magnitude of about 4.1 to the final value of 0. 671 after the consolidation was totally completed.

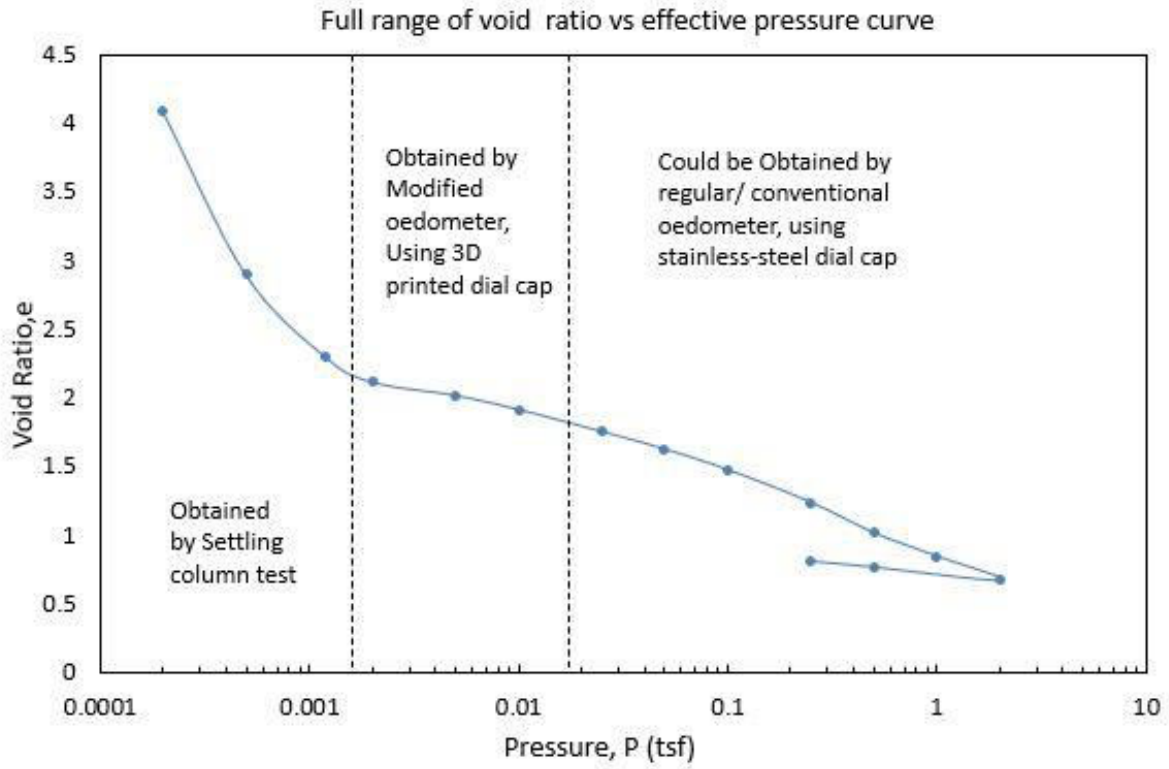


Figure 15. The combined effective pressure vs void ratio plot for the slurry sample with an initial water content of 210% .

Concluding Remarks

After analyzing the preliminary consolidation tests results following Method One and Method Two, a few fundamental conclusions could be drawn:

1. A small-scale settling column self-weight consolidation test and a conventional 1-D consolidometer test could be combined effectively to conduct consolidation test for soil slurries with an extremely high moisture content.
2. Use of the 3D-printed dial cap for the conventional 1-D consolidometer test could significantly reduce the sitting pressure from 0.01 TSF to 0.002 TSF. And thus, the much lighter dial cap could make the 1-D conventional consolidometer test handle a slurry sample with a water content as high as around 100%.
3. The research is very promising for the recommendation of a modified 1-D conventional consolidometer test by integrating the 3D printing technology and the small-scale settling column test.
4. By reviewing the settling column test results, it may be recommended that an acrylic plexiglass cylinder with a diameter of six inches or greater could be used for the small-scale settling column test.

Reference

Army, U. S. (1970). “Laboratory soils testing.” *Engineer Manual EM*, 1110-2–1906.

Army, U. S. (1987). “Confined disposal of dredged material” *Engineer Manual EM*, 1110-2–5027.

ASTM, A. (1996). “Standard test method for one-dimensional consolidation properties of soils.”

Azimi, A. (2018). “Laboratory Self-Weight Consolidation Testing of Dredged Material Analyzed Using a One-Dimensional Finite Strain Consolidation Method.” *Master of Science in Civil Engineering Theses.*, (Kennesaw State University, GA), https://digitalcommons.kennesaw.edu/msce_etd/2.

Azimi, A., Kaplan, A., and Rad, N. S. (2020). “A Simplified Self-Weight Consolidation Test Apparatus to Investigate the Consolidation Behavior of Dredged Material at Low Effective Stresses.” *Geo-Congress 2020: Modeling, Geomaterials, and Site Characterization*, American Society of Civil Engineers Reston, VA, 377–388.

Gao, Y.-F., Zhang, Y., Zhou, Y., and Li, D. (2016). “Effects of Column Diameter on Setting Behavior of Dredged Slurry in Sedimentation Experiments.” *Marine Georesources & Geotechnology*, Taylor & Francis, 34(5), 431–439.

Kondo, F., and Torrance, J. K. (2005). “Effects of smectite, salinity and water content on sedimentation and self-weight consolidation of thoroughly disturbed soft marine clay.” *Paddy and Water Environment*, Springer, 3(3), 155–164.

Lin, T.-W. (1983). “Sedimentation and self weight consolidation of dredge spoil.” Iowa State University.

Protection, C., and Authority, R. (2017). “Geotechnical Standards Marsh Creation and Coastal Restoration Projects.” 1–45.

Scott, J. D., Dusseault, M. B., and Carrier, W. D. (1986). “Large-scale self-weight consolidation testing.” *Consolidation of Soils: Testing and Evaluation*, ASTM international.

U.S. Army Corps of Engineers. (1987). “Confined disposal of dredged material.” 133.

University, T. A. (2007). “Ocean drilling program - http://www-odp.tamu.edu/publications/204_SR/102/102_3.htm.” *(College Station, TX)*.

Appendix A

Soil Characterization Test Results

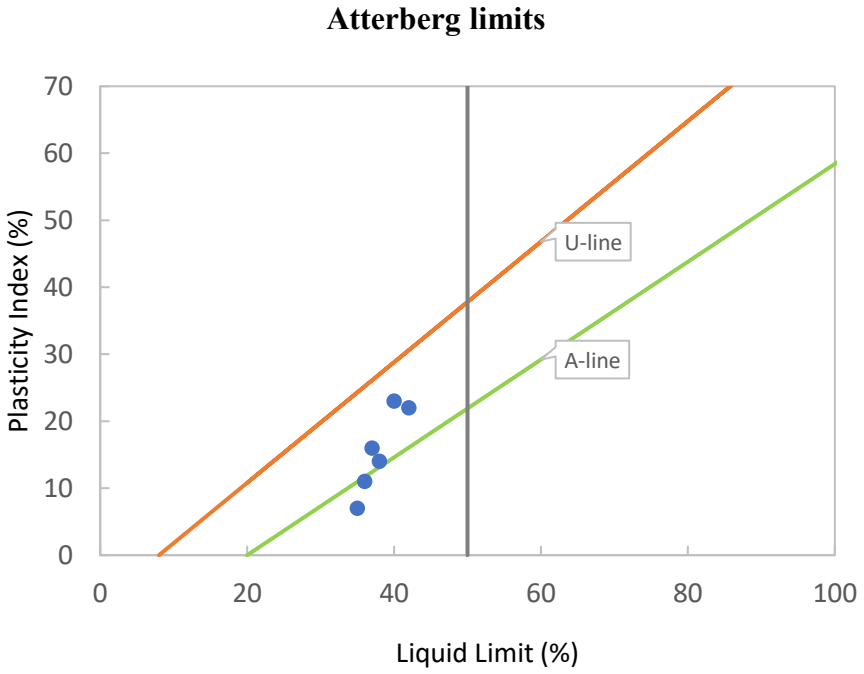


Figure 16. Liquid limit vs Plasticity index of the soil sample of No Name Bayou marsh creation project

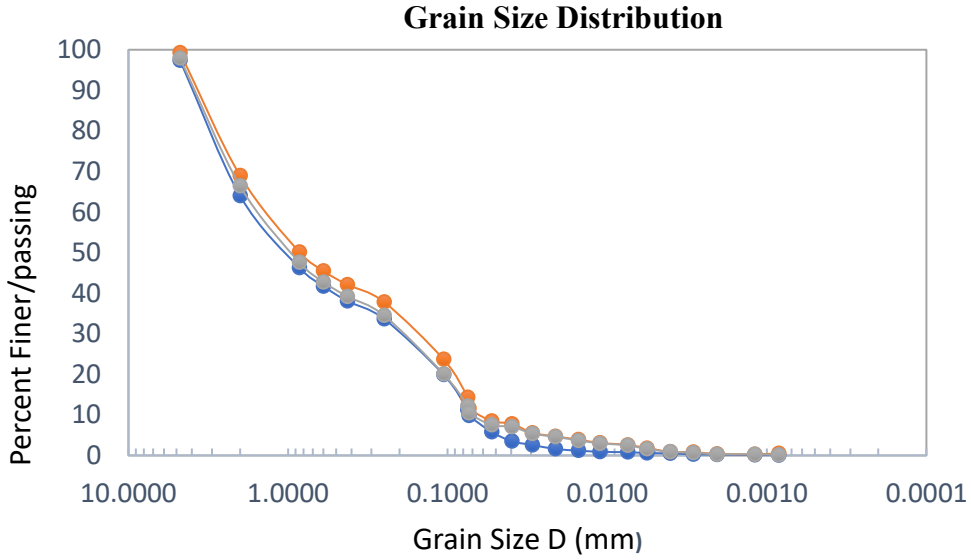


Figure 17. Grain size distribution of the soil sample of No-Name Bayou marsh creation project

Detailed analyses of the consolidation tests of slurry samples using conventional oedometer following Method One

Table 1. Calculations of void ratio and coefficient of consolidation of slurry sample having a moisture content of 60% using conventional oedometer

Moisture content of sample 60%						Height of Solids (in.)			0.4241	
Pressure P (ton/ft^2)	Final Dial Reading (in.)	Change in Specimen Height, ΔH (in.)	Final Specimen Height ,H_f (in.)	Height of Voids H_V (in.)	Final Void Ratio e	Average Height during consolidation (H_t)(av))(in)	Fitting time(sec)		C_V * 10^3 (in^2/sec)	
							T_{90}	T_{50}	T_{90}	T_{50}
0	0.002		1	0.576	1.358					
0.01	0.0898	0.0878	0.9122	0.488	1.151	0.956	1498.800	294	0.065	0.077
0.025	0.0976	0.0078	0.9044	0.480	1.132	0.908	2134.158	570	0.041	0.036
0.05	0.1436	0.046	0.8584	0.434	1.024	0.881	1921.457	546	0.043	0.035
0.1	0.1764	0.0328	0.8256	0.401	0.947	0.842	2142.755	432	0.035	0.040
0.25	0.2677	0.0913	0.7343	0.310	0.731	0.780	2832.638	480	0.023	0.031
0.5	0.3905	0.1228	0.6115	0.187	0.442	0.673	3195.648	474	0.015	0.024
1	0.4747	0.0842	0.5273	0.103	0.243	0.569	2343.000	366	0.015	0.022
Unloading										
0.5	0.4733	0.0014	0.5287	0.105	0.247					
0.1	0.4677	0.0056	0.5343	0.110	0.260					

Table 2. Calculations of void ratio and coefficient of consolidation of slurry sample having a moisture content of 50% using conventional oedometer

Moisture content of the sample 50%						Height of Solids (in.)		0.4891		
Pressure P (ton/ft^2)	Final Dial Reading (in.)	Change in Specimen Height, ΔH (in.)	Final Specimen Height ,H_f (in.)	Height of voids H_V (in.)	Final Void Ratio e	Average Height during consolidation $(H_t)(av))$(in)	Fitting time(sec)		C_V * 10^3 (in^2/sec)	
							T_{90}	T_{50}	T_{90}	T_{50}
0	0.003		1	0.511	1.044					
0.01	0.0888	0.0858	0.9142	0.425	0.869	0.957	1560.6	240	0.062	0.094
0.025	0.0966	0.0079	0.9064	0.417	0.853	0.910	4752.6	540	0.018	0.038
0.05	0.1186	0.0220	0.8844	0.395	0.808	0.895	3375.0	330	0.025	0.060
0.1	0.1471	0.0285	0.8559	0.367	0.750	0.870	3024.6	600	0.027	0.031
0.25	0.2161	0.0690	0.7869	0.298	0.609	0.821	5078.4	612	0.014	0.027
0.5	0.3052	0.0891	0.6978	0.209	0.427	0.742	5880.6	606	0.010	0.022
1	0.3752	0.0700	0.6278	0.139	0.283	0.663	3110.4	624	0.015	0.017
Unloading										
0.5	0.3741	0.0011	0.6289	0.140	0.286					
0.1	0.3694	0.0047	0.6336	0.144	0.295					

Table 3. Calculations of void ratio and coefficient of consolidation of slurry sample having a moisture content of 40% using conventional oedometer

Moisture content of the soi sample 40%						Height of Solids (in.)			0.5623	
Pressure P (ton/ft^2)	Final Dial Reading (in.)	Change in Specimen Height, ΔH (in.)	Final Specimen Height ,H_f (in.)	Height of voids H_V (in.)	Final Void Ratio e	Average Height during consolidation $(H_t)(av))(in)$	Fitting time(sec)		C_V * 10^3 (in^2/sec)	
							T_{90}	T_{50}	T_{90}	T_{50}
0	0.004		1	0.438	0.778					
0.01	0.0798	0.0758	0.9242	0.362	0.644	0.962	1560.6	120	0.063	0.190
0.025	0.087	0.0072	0.917	0.355	0.631	0.921	1622.4	66	0.055	0.316
0.05	0.0998	0.0128	0.9042	0.342	0.608	0.911	1382.4	114	0.064	0.179
0.1	0.1137	0.0139	0.8903	0.328	0.583	0.897	1008.6	120	0.085	0.165
0.25	0.1551	0.0414	0.8489	0.287	0.51	0.870	1109.4	126	0.072	0.148
0.5	0.1925	0.0374	0.8115	0.249	0.443	0.830	1440.6	108	0.051	0.157
1	0.2421	0.0496	0.7619	0.200	0.355	0.787	1560.6	144	0.042	0.106
Unloading										
0.5	0.2414	0.0007	0.7626	0.200	0.356					
0.1	0.238	0.0034	0.766	0.204	0.362					

Detail analyses of the consolidation tests of slurry samples using settling column and modified oedometer following Method Two

Table 4. Calculations of pressure and void ratio for slurry sample in the 10″ diameter settling column test.

Layer	Tray wt. (gm)	Moist Soil + Tray wt. (gm)	Dry Soil + Tray wt. (gm)	Net Moist wt. (gm)	Wt. of Solid (gm)	Wt. of Water (gm)	Moisture Content (%)	volume of Solids (cc)	volume of Water (cc)	Total Volume (cc)	Height of Layer (cm)	Height of Solids (cm)	Buoyant wt. of Solids (gm)	Effective Stress (gm/cm^2)	Effective Stress (TSF)	Void Ratio
1	90.2	1225	533.5	1134.8	443.3	691.5	156	170.5	691.5	862	2.54	0.327	272.8	0.167	0.0002	4.1
2	92.6	2021.8	1066.9	1929.2	974.3	954.9	98.1	374.8	954.9	1329.7	2.54	0.717	599.5	0.532	0.0005	2.6
3	93.7	3044.2	1758.4	2950.5	1664.7	1285.8	77.3	640.3	1285.8	1926.1	2.54	1.225	1024.4	1.156	0.0011	2.1

Table 5. Calculations of pressure and void ratio for soil sample in the 8″ diameter settling column test.

Layer	Tray wt. (gm)	Moist Soil + Tray wt. (gm)	Dry Soil + Tray wt. (gm)	Net Moist wt. (gm)	Wt. of Solid (gm)	Wt. of Water (gm)	Moisture Content (%)	volume of Solids (cc)	volume of Water (cc)	Total Volume (cc)	Height of Layer (cm)	Height of Solids (cm)	Buoyant wt. of Solids (gm)	Effective Stress (gm/cm^2)	Effective Stress (TSF)	Void Ratio
1	244.8	977.1	529.7	732.3	284.9	447.4	157.1	109.6	447.4	557	2.54	0.21	175.3	0.168	0.0002	4.1
2	107.5	1279.1	687.5	1171.6	580	591.6	102	223.1	591.6	814.7	2.54	0.427	356.9	0.509	0.0005	2.7
3	93.3	1924	1116.4	1830.7	1023.1	807.6	79	393.5	807.6	1201.1	2.54	0.753	629.6	1.109	0.0011	2.1

Table 6. Calculation of pressure and void ratio for soil sample in the 6″ diameter settling column test.

Layer	Tray wt. (gm)	Moist Soil + Tray wt. (gm)	Dry Soil + Tray wt. (gm)	Net Moist wt. (gm)	Wt. of Solid (gm)	Wt. of Water (gm)	Moisture Content (%)	volume of Solids (cc)	volume of Water (cc)	Total Volume (cc)	Height of Layer (cm)	Height of Solids (cm)	Buoyant wt. of Solids (gm)	Effective Stress (gm/cm^2)	Effective Stress (TSF)	Void Ratio
1	87.5	527.6	260.4	440.1	172.9	267.2	154.6	66.5	267.2	333.7	2.54	0.128	106.4	0.181	0.0002	4.1
2	230.6	934.8	566	704.2	335.4	368.8	110	129	368.8	497.8	2.54	0.247	206.4	0.532	0.0005	2.9
3	231.2	1234.7	764.4	1003.5	533.2	470.3	88.3	205.1	470.3	675.4	2.54	0.393	328.1	1.09	0.001	2.3

Table 7. Calculations of void ratio and coefficient of consolidation of slurry sample having a moisture content of 100.1 % using conventional oedometer

Moisture content of the sample 100%						Height of Solids (in.)=			0.2807	
Pressure P (ton/ft^2)	Final Dial Reading (in.)	Change in Specimen Height, ΔH (in.)	Final Specimen Height ,H_f (in.)	Height of voids H_V (in.)	Final Void Ratio e	Average Height during consolidation $(H_t)(av))$(in)	Fitting time(sec)		C_V * 10^3 (in^2/sec)	
							T_{90}	T_{50}	T_{90}	T_{50}
0	0.002		1	0.719	2.563					
0.002	0.1272	0.1252	0.8748	0.594	2.117	0.937	1215	150	0.077	0.144
0.005	0.1544	0.0272	0.8476	0.567	2.02	0.861	2940	606	0.027	0.030
0.01	0.1829	0.0285	0.8191	0.538	1.918	0.833	2160	612	0.034	0.028
0.025	0.2283	0.0454	0.7737	0.493	1.757	0.796	2160	420	0.031	0.037
0.05	0.2642	0.0359	0.7378	0.457	1.629	0.756	31740	9000	0.002	0.002
0.1	0.3063	0.0421	0.6957	0.415	1.479	0.717	7260	1740	0.008	0.007
0.25	0.3733	0.067	0.6287	0.348	1.240	0.662	1500	510	0.031	0.021
0.5	0.4358	0.0625	0.5662	0.286	1.017	0.597	8074	1860	0.005	0.005
1	0.4839	0.0481	0.5181	0.237	0.846	0.542	3840	660	0.008	0.011
2	0.5329	0.049	0.4691	0.188	0.671	0.494	960	390	0.027	0.015
Unloading										
0.5	0.5067	0.0262	0.4953	0.215	0.765					
0.25	0.4943	0.0124	0.5077	0.227	0.809					

Detailed analyses of permeabilities of slurry samples in the consolidation tests using conventional oedometer

Table 8. Calculations of permeabilities of slurry sample having a moisture content of 60%

Pressure P (ton/ft^2)	Final Void Ratio e	Fitting time(sec)		C_V * 10^3 (in^2/sec)		Δe	Δσ (ton/ft^2)	$(1+e_{av})$	K * 10^5 (in/sec)	
		T_{90}	T_{50}	T_{90}	T_{50}				T_{90}	T_{50}
0.01	1.151	1499	294	0.065	0.077	0.207	0.010	2.255	0.155	0.184
0.025	1.132	2134	570	0.041	0.036	0.019	0.015	2.142	0.006	0.006
0.05	1.024	1921	546	0.043	0.035	0.108	0.025	2.078	0.023	0.019
0.1	0.947	2143	432	0.035	0.040	0.077	0.050	1.986	0.007	0.008
0.25	0.731	2833	480	0.023	0.031	0.216	0.150	1.839	0.005	0.006
0.5	0.442	3196	474	0.015	0.024	0.289	0.250	1.587	0.003	0.005
1	0.243	2343	366	0.015	0.022	0.199	0.500	1.343	0.001	0.002

Table 9. Calculations of permeabilities of slurry sample having a moisture content of 50%

Pressure P (ton/ft^2)	Final Void Ratio e	Fitting time(sec)		C_V * 10^3 (in^2/sec)		Δe	Δσ (ton/ft^2)	$(1+e_{av})$	K * 10^5 (in/sec)	
		T_{90}	T_{50}	T_{90}	T_{50}				T_{90}	T_{50}
0.01	0.869	1561	240	0.062	0.094	0.175	0.010	1.957	0.144	0.219
0.025	0.853	4753	540	0.018	0.038	0.016	0.015	1.861	0.003	0.006
0.05	0.808	3375	330	0.025	0.060	0.045	0.025	1.831	0.006	0.015
0.1	0.75	3025	600	0.027	0.031	0.058	0.050	1.779	0.005	0.005
0.25	0.609	5078	612	0.014	0.027	0.141	0.150	1.680	0.002	0.004
0.5	0.427	5881	606	0.010	0.022	0.182	0.250	1.518	0.001	0.003
1	0.283	3110	624	0.015	0.017	0.144	0.500	1.355	0.001	0.001

Table 10. Calculations of permeabilities of slurry sample having a moisture content of 40%

Pressure P (ton/ft^2)	Final Void Ratio e	Fitting time(sec)		C_V * 10^3 (in^2/sec)		Δe	Δσ (ton/ft^2)	$(1+e_{av})$	K * 10^5 (in/sec)	
		T_{90}	T_{50}	T_{90}	T_{50}				T_{90}	T_{50}
0.01	0.644	1561	120	0.063	0.190	0.134	0.010	1.711	0.128	0.387
0.025	0.631	1622	66	0.055	0.316	0.013	0.015	1.638	0.008	0.043
0.05	0.608	1382	114	0.064	0.179	0.023	0.025	1.620	0.009	0.026
0.1	0.583	1009	120	0.085	0.165	0.025	0.050	1.596	0.007	0.013
0.25	0.51	1109	126	0.072	0.148	0.073	0.150	1.547	0.006	0.012
0.5	0.443	1441	108	0.051	0.157	0.067	0.250	1.477	0.002	0.007
1	0.355	1561	144	0.042	0.106	0.088	0.500	1.399	0.001	0.003

Detailed analyses of permeabilites of slurry samples in the settling column tests

Table 11. Calculations of permeabilities for slurry sample in the 10″diameter settling column test.

Effective pressure (gm/cm^2)	Degree of Consolidation (%)	Time factor	Ave. void ratio	Height of solid (cm)	Time (sec)	Coeff. Of compression ($d\sigma'/de$)	Coeff of consol. (cm^2/sec)	Permeability (cm/sec)
0.167	20	0.1	4.1	0.327	4000	0.040732	2.67323E-06	0.000334713
0.532	50	0.3	2.6	0.717	30240	0.243333	5.10009E-06	7.54534E-05
1.156	90	1	2.1	1.225	157464	1.248	9.52996E-06	2.36722E-05

Table 12. Calculations of permeabilities for slurry sample in the 8″ diameter settling column test.

Effective pressure (gm/cm^2)	Degree of Consolidation (%)	Time factor	Ave. void ratio	Height of solid (cm)	Time (sec)	Coeff. Of compression ($d\sigma'/de$)	Coeff of consol. (cm^2/sec)	Permeability (cm/sec)
0.168	20	0.1	4.1	0.21	5000	0.040976	0.000000882	0.000109778
0.509	50	0.3	2.7	0.427	31104	0.243571	1.75857E-06	2.67138E-05
1.109	90	1	2.1	0.753	164540.2	1	3.44602E-06	1.06827E-05

Table 13. Calculations of permeabilities for slurry sample in the 6″ diameter settling column test.

Effective pressure (gm/cm^2)	Degree of Consolidation (%)	Time factor	Ave. void ratio	Height of solid (cm)	Time (sec)	Coeff. Of compression ($d\sigma'/de$)	Coeff of consol. (cm^2/sec)	Permeability (cm/sec)
0.181	20	0.1	4.1	0.128	6000	0.044146	2.73067E-07	3.1546E-05
0.532	50	0.3	2.9	0.247	31968	0.2925	5.72532E-07	7.63376E-06
1.09	90	1	2.3	0.393	174217	0.93	8.86533E-07	3.14576E-06

Detail analyses of permeabilities of slurry samples of the consolidation test using modified oedometer

Table 14. Calculations of permeabilities of slurry sample having a moisture content of 100.1%

Pressure P (ton/ft^2)	Final Void Ratio e	Fitting time(sec)		C_V * 10^3 (in^2/sec)		Δe	Δσ (ton/ft^2)	$(1+e_{av})$	K * 10^5 (in/sec)	
		T_{90}	T_{50}	T_{90}	T_{50}				T_{90}	T_{50}
0.002	2.117	1215	150	0.077	0.144	0.446	0.002	3.340	1.337	2.500
0.005	2.02	2940	606	0.027	0.030	0.097	0.003	3.069	0.074	0.082
0.01	1.918	2160	612	0.034	0.028	0.102	0.005	2.969	0.061	0.050
0.025	1.757	2160	420	0.031	0.037	0.161	0.015	2.838	0.030	0.036
0.05	1.629	31740	9000	0.002	0.002	0.128	0.025	2.693	0.001	0.001
0.1	1.479	7260	1740	0.008	0.007	0.150	0.050	2.554	0.002	0.002
0.25	1.24	1500	510	0.031	0.021	0.239	0.150	2.360	0.005	0.004
0.5	1.017	8074	1860	0.005	0.005	0.223	0.250	2.129	0.001	0.001
1	0.846	3840	660	0.008	0.011	0.171	0.500	1.932	0.000	0.001
2	0.671	960	390	0.027	0.015	0.175	1.000	1.759	0.001	0.000

Appendix B

Table 15. Time versus vertical dial readings of slurry sample having a moisture content of 60% using conventional oedometer.

Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.01			
Time t (min)	Sqrt of t (min)^0.5	Vertical dial reading (in)	% Strain change
0	0	0	0
0.5	0.707107	0.0172	19.2
1	1	0.0298	33.2
2	1.414214	0.0398	44.3
4	2	0.0474	52.8
8	2.828427	0.0579	64.5
15	3.872983	0.0689	76.7
30	5.477226	0.081	90.2
60	7.745967	0.0862	96
120	10.95445	0.0888	98.9
240	15.49193	0.0892	99.3
480	21.9089	0.0895	99.7
1440	37.94733	0.0898	100

Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.025			
Time t (min)	Sqrt of t (min)^0.5	Vertical dial reading (in))	% Strain change
0	0	0.0898	0
0.5	0.707107	0.0899	1.3
1	1	0.0902	5.1
2	1.414214	0.0906	10.3
4	2	0.0909	14.1
8	2.828427	0.0918	25.6
15	3.872983	0.0932	43.6
30	5.477226	0.0956	74.4
60	7.745967	0.0965	85.9
120	10.95445	0.097	92.3
240	15.49193	0.0973	96.2
480	21.9089	0.0975	98.7
1440	37.94733	0.0976	100

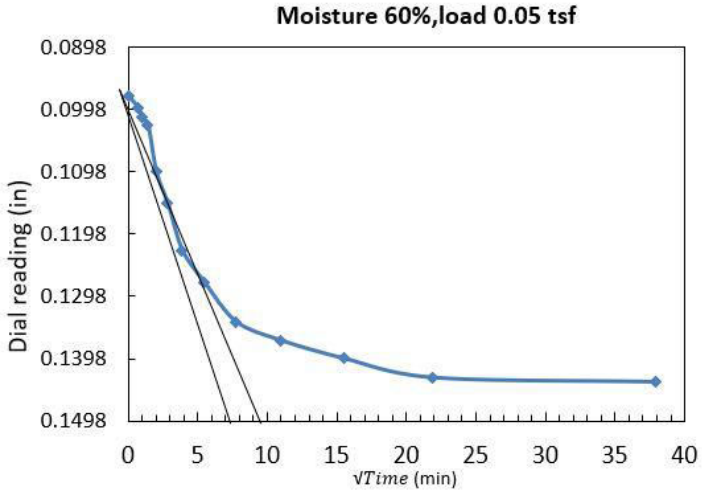
Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.05			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0976	0
0.5	0.707107	0.0995	4.1
1	1	0.1011	7.6
2	1.414214	0.1023	10.2
4	2	0.1098	26.5
8	2.828427	0.1149	37.6
15	3.872983	0.1224	53.9
30	5.477226	0.1276	65.2
60	7.745967	0.1339	78.9
120	10.95445	0.1369	85.4
240	15.49193	0.1398	91.7
480	21.9089	0.1429	98.5
1440	37.94733	0.1436	100

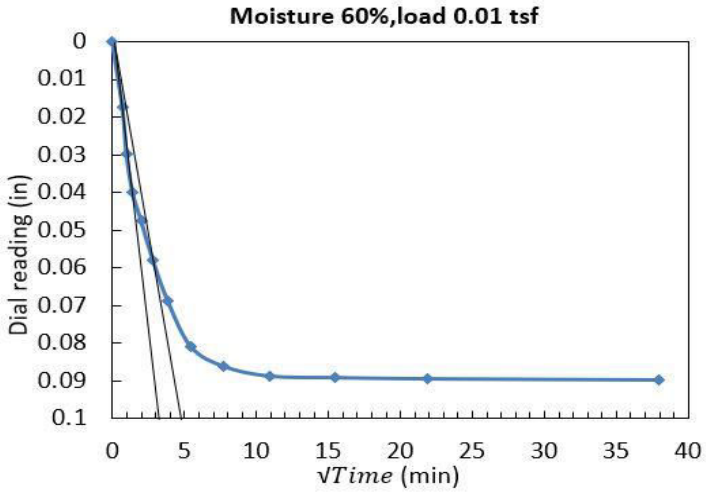
Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1436	0
0.5	0.707107	0.1448	3.7
1	1	0.1457	6.4
2	1.414214	0.1478	12.8
4	2	0.1539	31.4
8	2.828427	0.1598	49.4
15	3.872983	0.1643	63.1
30	5.477226	0.1678	73.8
60	7.745967	0.1709	83.2
120	10.95445	0.1729	89.3
240	15.49193	0.1749	95.4
480	21.9089	0.1756	97.6
1440	37.94733	0.1764	100

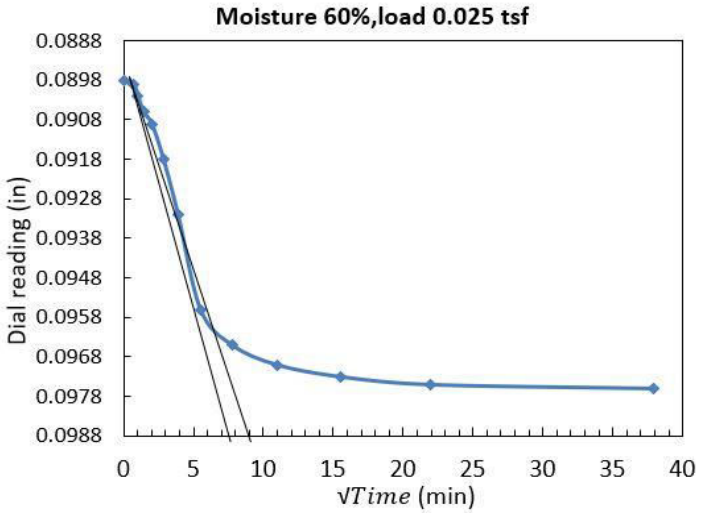
Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.25			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1764	0
0.5	0.707107	0.1802	4.2
1	1	0.1898	14.7
2	1.414214	0.1972	22.8
4	2	0.2157	43
8	2.828427	0.2264	54.8
15	3.872983	0.2327	61.7
30	5.477226	0.2405	70.2
60	7.745967	0.2497	80.3
120	10.95445	0.2568	88.1
240	15.49193	0.2647	96.7
480	21.9089	0.2661	98.2
1440	37.94733	0.2677	100

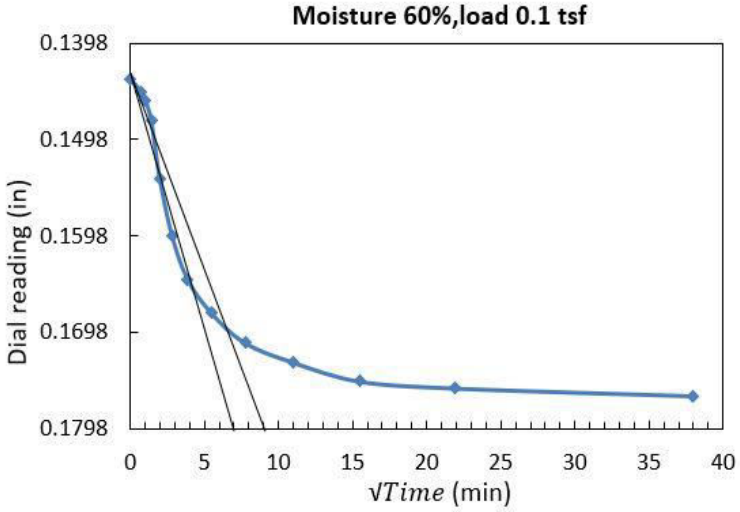
Sample: 60% moisture content			
Pressure on specimen (TSF) = 0.5			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.2677	0
0.5	0.707107	0.2741	5.2
1	1	0.2829	12.4
2	1.414214	0.3023	28.2
4	2	0.3134	37.2
8	2.828427	0.3243	46.1
15	3.872983	0.3417	60.3
30	5.477226	0.3612	76.1
60	7.745967	0.3702	83.5
120	10.95445	0.3798	91.3
240	15.49193	0.3857	96.1
480	21.9089	0.3889	98.7
1440	37.94733	0.3905	100

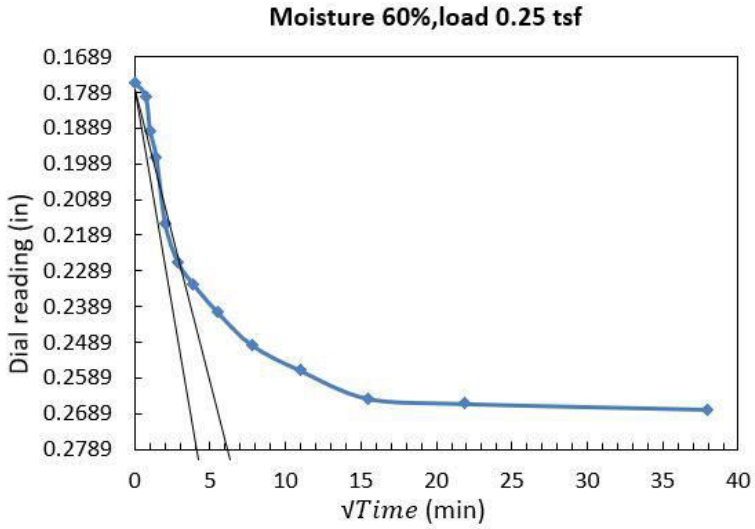
Sample: 60% moisture content			
Pressure on specimen (TSF) = 1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.3905	0
0.5	0.707107	0.3988	9.9
1	1	0.4076	20.3
2	1.414214	0.4188	33.6
4	2	0.4276	44.1
8	2.828427	0.4367	54.9
15	3.872983	0.4498	70.4
30	5.477226	0.4569	78.9
60	7.745967	0.4611	83.8
120	10.95445	0.4651	88.6
240	15.49193	0.4691	93.3
480	21.9089	0.4723	97.1
1440	37.94733	0.4747	100

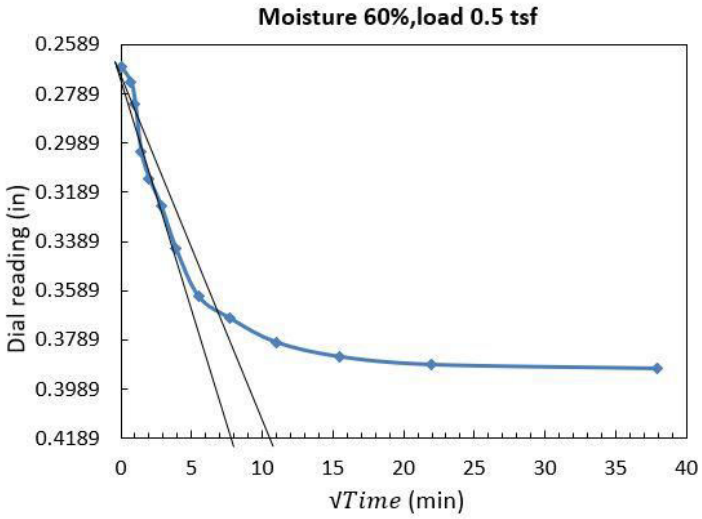

Moisture 60%,load 0.05 tsf
Dial reading (in)
0.0898
0.0998
0.1098
0.1198
0.1298
0.1398
0.1498
0 5 10 15 20 25 30 35 40
√Time (min)


Moisture 60%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0 5 10 15 20 25 30 35 40
√Time (min)


Moisture 60%,load 0.025 tsf
Dial reading (in)
0.0888
0.0898
0.0908
0.0918
0.0928
0.0938
0.0948
0.0958
0.0968
0.0978
0.0988
0 5 10 15 20 25 30 35 40
√Time (min)


Moisture 60%,load 0.1 tsf
Dial reading (in)
0.1398
0.1498
0.1598
0.1698
0.1798
0 5 10 15 20 25 30 35 40
√Time (min)





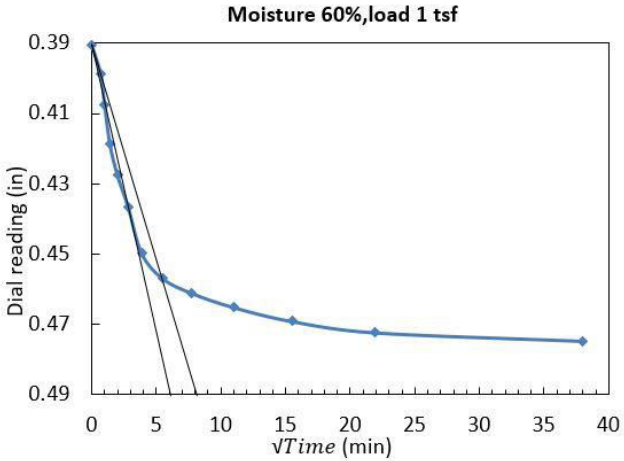
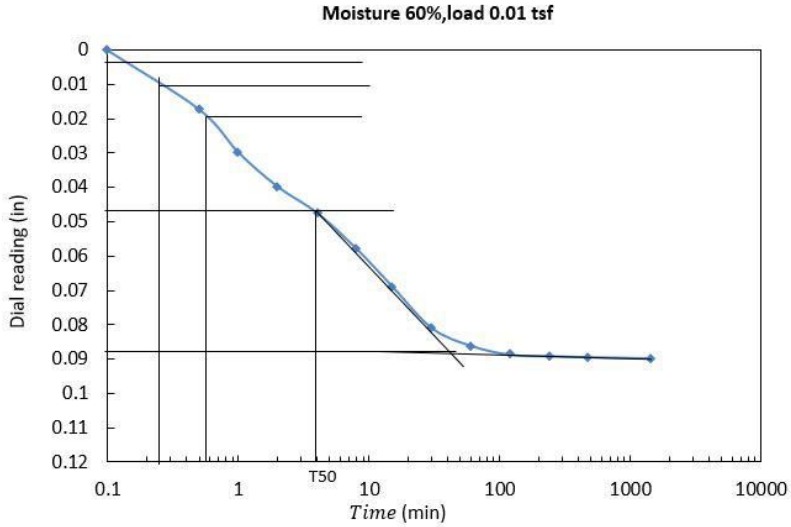
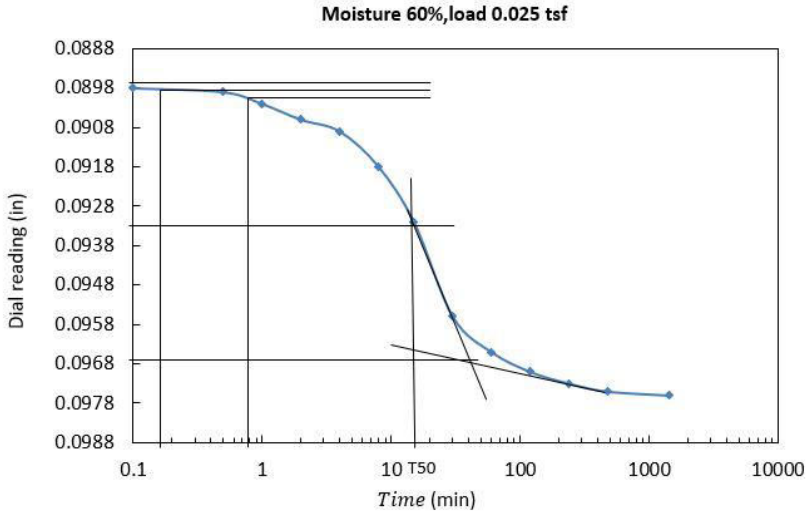
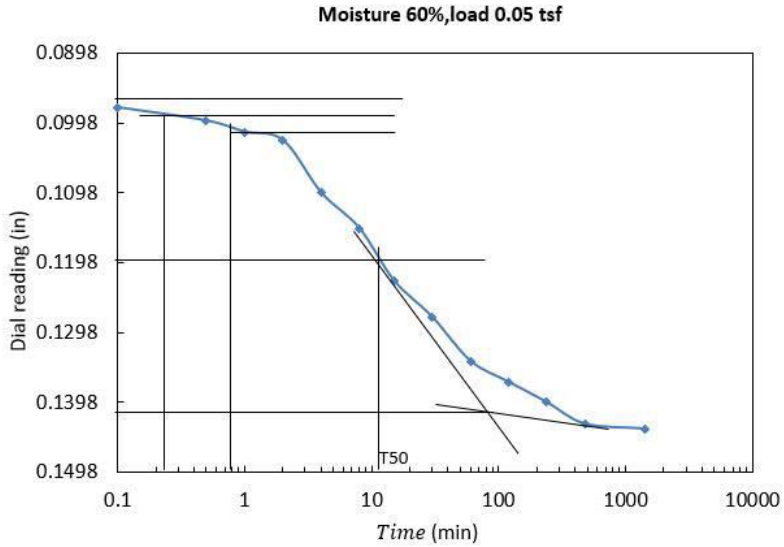
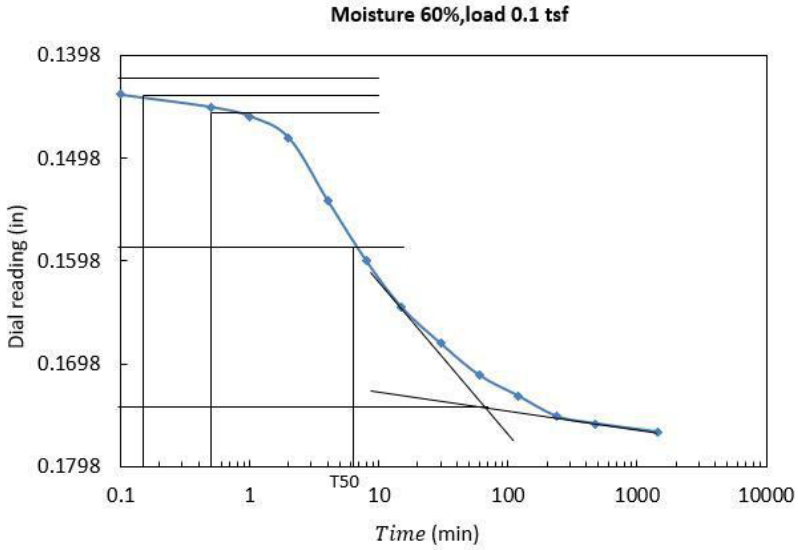


Figure 18. Determination of T_{90} of slurry sample having a moisture content of 60% using conventional oedometer and following Method One


Moisture 60%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.1
1
T50
10
100
1000
10000
Time (min)


Moisture 60%,load 0.025 tsf
Dial reading (in)
0.0888
0.0898
0.0908
0.0918
0.0928
0.0938
0.0948
0.0958
0.0968
0.0978
0.0988
0.1
1
10
T50
100
1000
10000
Time (min)


Moisture 60%,load 0.05 tsf
Dial reading (in)
0.0898
0.0998
0.1098
0.1198
0.1298
0.1398
0.1498
0.1
1
10
T50
100
1000
10000
Time (min)


Moisture 60%,load 0.1 tsf
Dial reading (in)
0.1398
0.1498
0.1598
0.1698
0.1798
0.1
1
T50
10
100
1000
10000
Time (min)

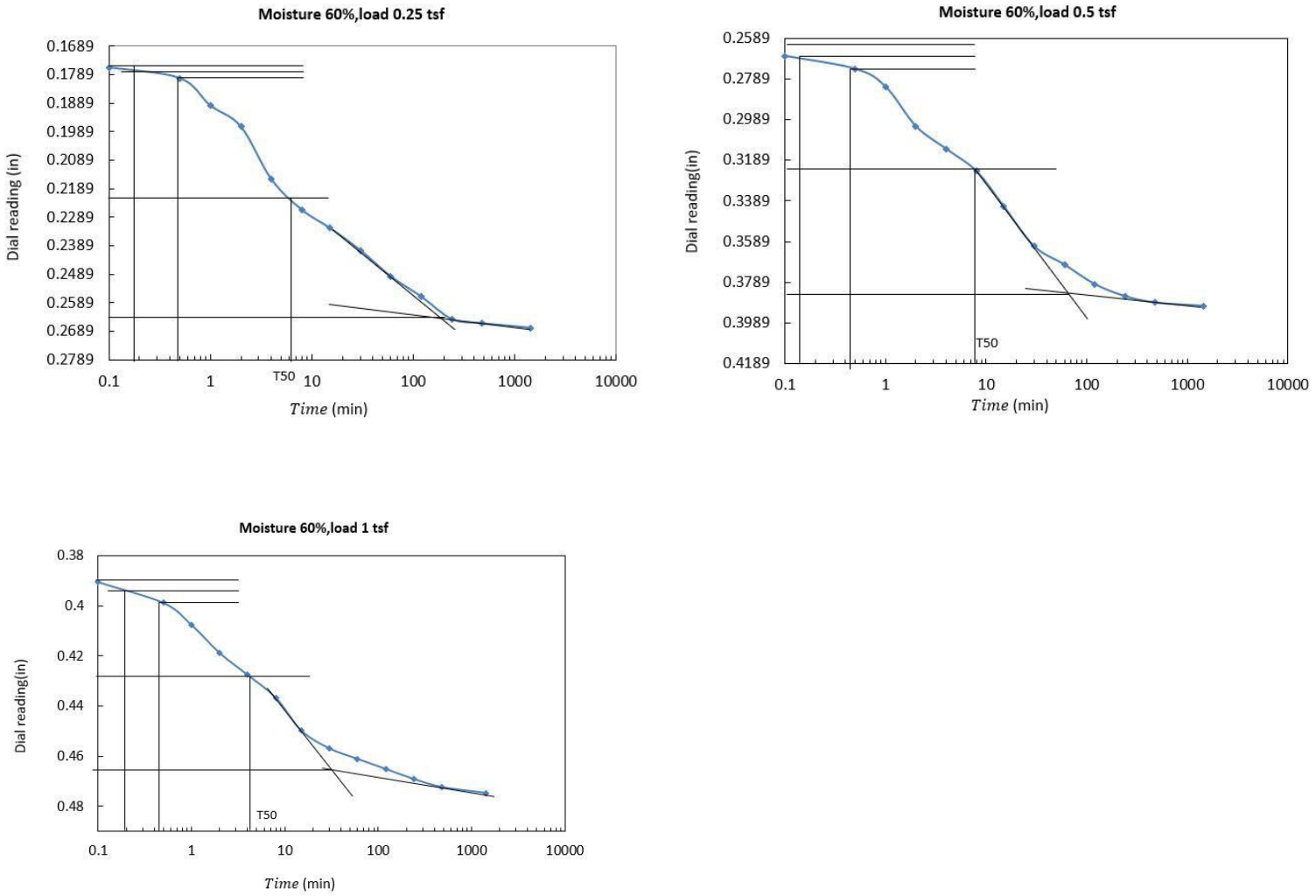


Figure 19. Determination of T_{50} of slurry sample having a moisture content of 60% using conventional oedometer and following Method One

Table 16. Time versus vertical dial readings of slurry sample having a moisture content of 50% using conventional oedometer.

Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.01			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0	0
0.5	0.707107	0.0172	19.4
1	1	0.0298	33.6
2	1.414214	0.0398	44.8
4	2	0.0474	53.4
8	2.828427	0.0579	65.2
15	3.872983	0.0689	77.6
30	5.477226	0.081	91.2
60	7.745967	0.0862	97.1
120	10.95445	0.0882	99.3
240	15.49193	0.0884	99.5
480	21.9089	0.0886	99.8
1440	37.94733	0.0888	100

Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.025			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0888	0
0.5	0.707107	0.0899	14.1
1	1	0.0902	17.9
2	1.414214	0.0906	23.1
4	2	0.0909	26.9
8	2.828427	0.0918	38.5
15	3.872983	0.0932	56.4
30	5.477226	0.0946	74.4
60	7.745967	0.0951	80.8
120	10.95445	0.0956	87.2
240	15.49193	0.0959	91
480	21.9089	0.0962	94.9
1440	37.94733	0.0966	100

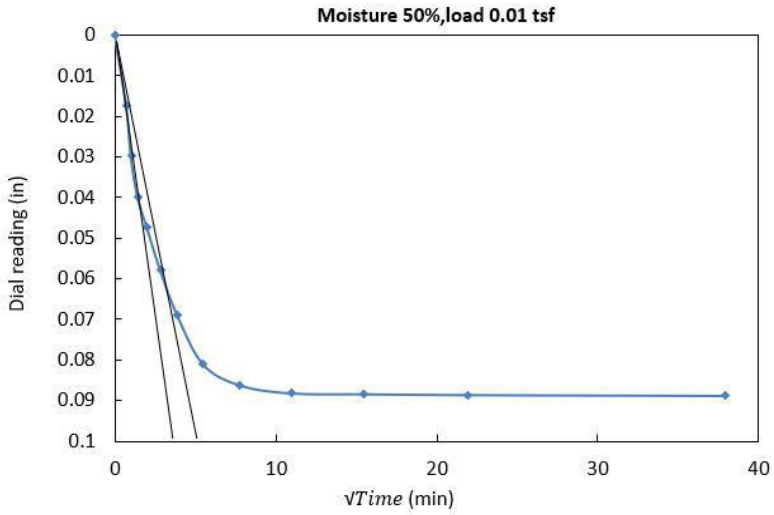
Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.05			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0966	0
0.5	0.707107	0.0995	13.2
1	1	0.1011	20.5
2	1.414214	0.1023	25.9
4	2	0.1058	41.8
8	2.828427	0.1076	50
15	3.872983	0.1104	62.7
30	5.477226	0.1126	72.7
60	7.745967	0.1143	80.5
120	10.95445	0.1169	92.3
240	15.49193	0.1174	94.5
480	21.9089	0.1179	96.8
1440	37.94733	0.1186	100

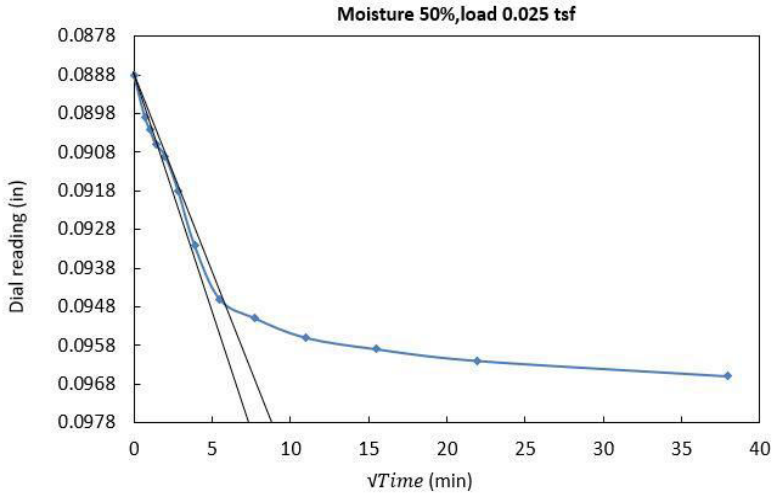
Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1186	0
0.5	0.707107	0.1208	7.7
1	1	0.1237	17.9
2	1.414214	0.1268	28.8
4	2	0.1279	32.6
8	2.828427	0.1308	42.8
15	3.872983	0.1347	56.5
30	5.477226	0.1378	67.4
60	7.745967	0.1409	78.2
120	10.95445	0.1436	87.7
240	15.49193	0.1449	92.3
480	21.9089	0.1465	97.9
1440	37.94733	0.1471	100

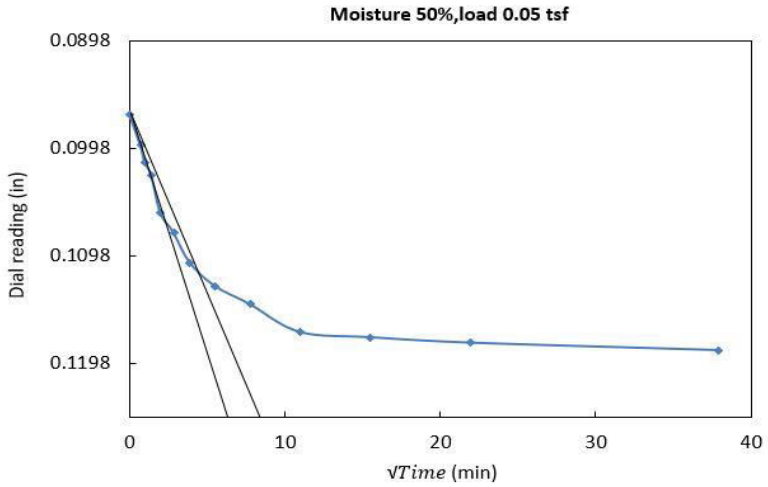
Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.25			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1471	0
0.5	0.707107	0.1532	8.8
1	1	0.1578	15.5
2	1.414214	0.1632	23.3
4	2	0.1687	31.3
8	2.828427	0.1756	41.3
15	3.872983	0.1847	54.5
30	5.477226	0.1989	75.1
60	7.745967	0.2057	84.9
120	10.95445	0.2108	92.3
240	15.49193	0.2127	95.1
480	21.9089	0.2152	98.7
1440	37.94733	0.2161	100

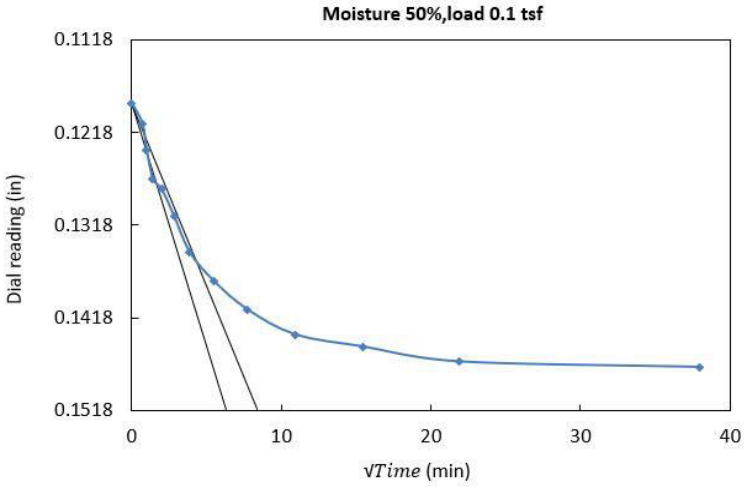
Sample: 50% moisture content			
Pressure on specimen (TSF) = 0.5			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.2161	0
0.5	0.707107	0.2229	7.6
1	1	0.2329	18.9
2	1.414214	0.2393	26
4	2	0.2434	30.6
8	2.828427	0.2543	42.9
15	3.872983	0.2637	53.4
30	5.477226	0.2782	69.7
60	7.745967	0.2895	82.4
120	10.95445	0.2978	91.7
240	15.49193	0.3017	96.1
480	21.9089	0.3046	99.3
1440	37.94733	0.3052	100

Sample: 50% moisture content			
Pressure on specimen (TSF) = 1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.3052	0
0.5	0.707107	0.3118	9.4
1	1	0.3196	20.6
2	1.414214	0.3238	26.6
4	2	0.3306	36.3
8	2.828427	0.3367	45
15	3.872983	0.3438	55.1
30	5.477226	0.3543	70.1
60	7.745967	0.3641	84.1
120	10.95445	0.3691	91.2
240	15.49193	0.3719	95.2
480	21.9089	0.3743	98.7
1440	37.94733	0.3752	100


Moisture 50%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0
10
20
30
40
√Time (min)


Moisture 50%,load 0.025 tsf
Dial reading (in)
0.0878
0.0888
0.0898
0.0908
0.0918
0.0928
0.0938
0.0948
0.0958
0.0968
0.0978
0
5
10
15
20
25
30
35
40
√Time (min)


Moisture 50%,load 0.05 tsf
Dial reading (in)
0.0898
0.0998
0.1098
0.1198
0
10
20
30
40
√Time (min)


Moisture 50%,load 0.1 tsf
Dial reading (in)
0.1118
0.1218
0.1318
0.1418
0.1518
0
10
20
30
40
√Time (min)

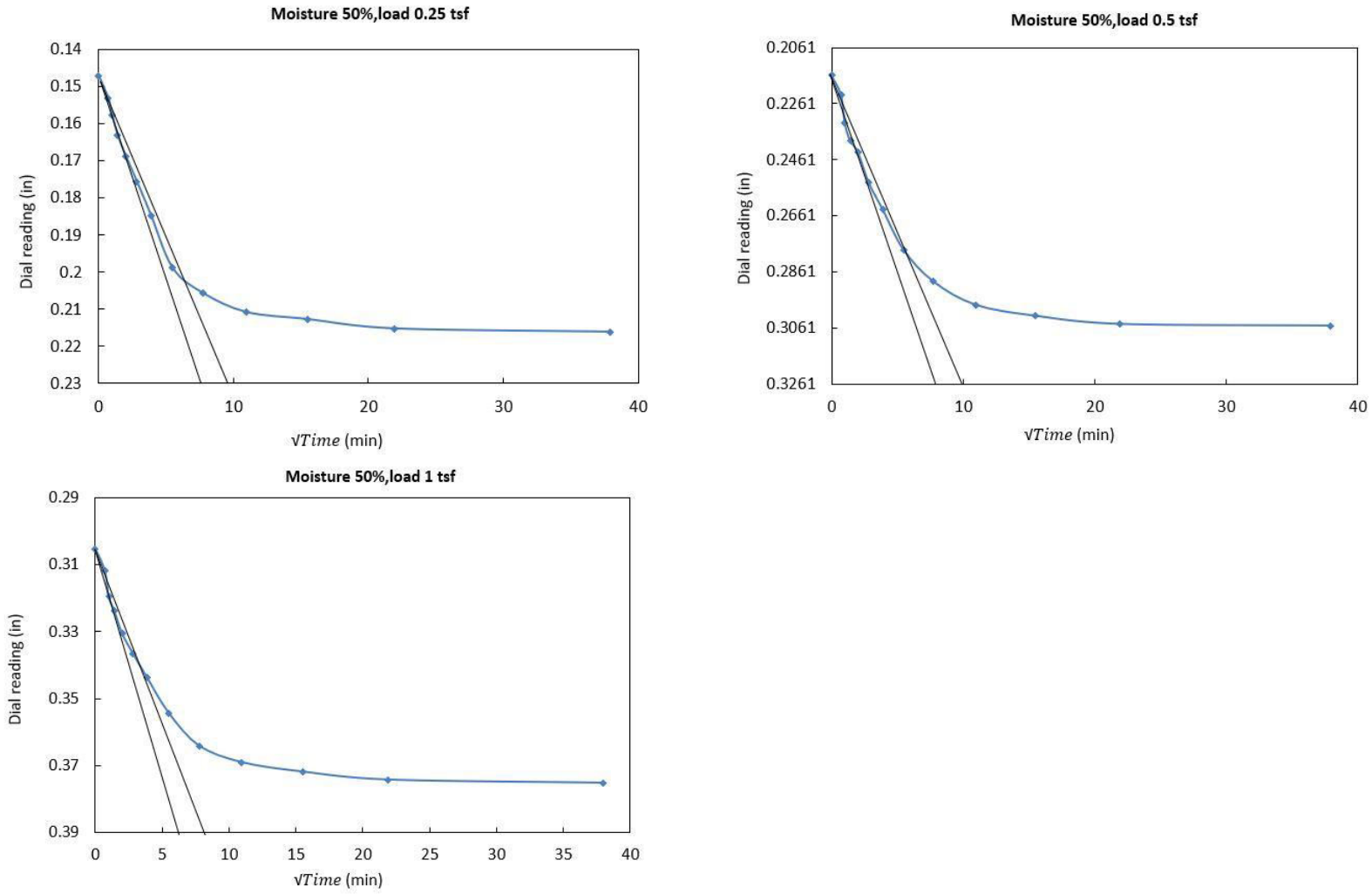
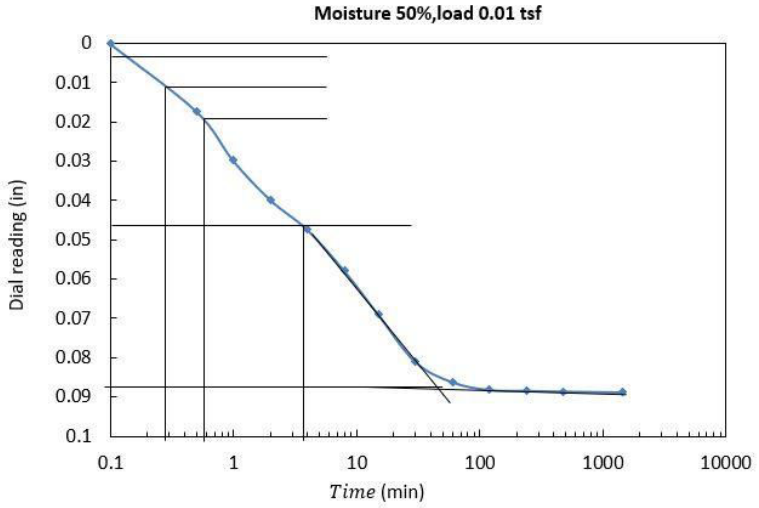
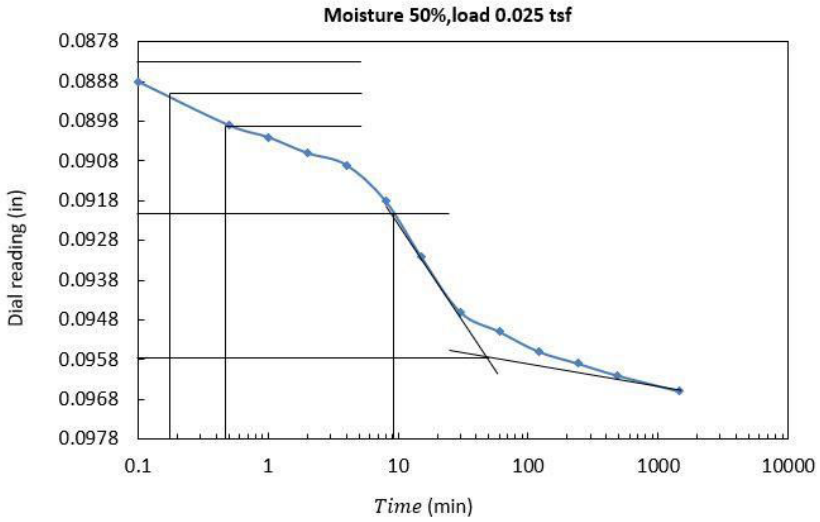
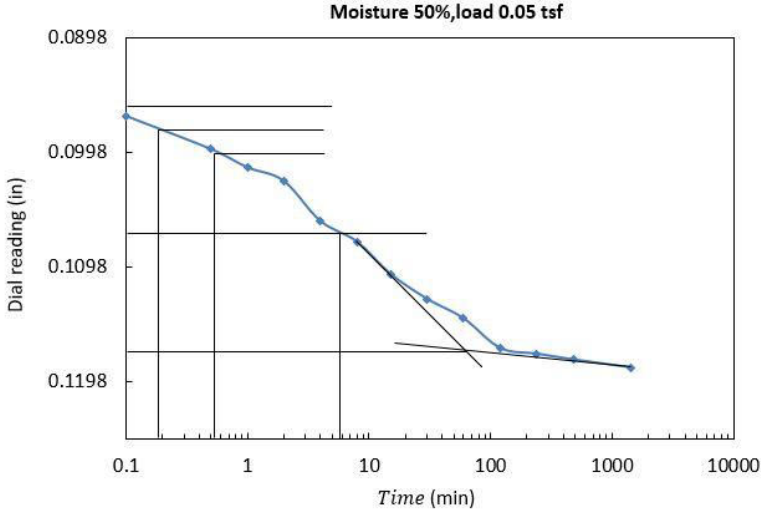
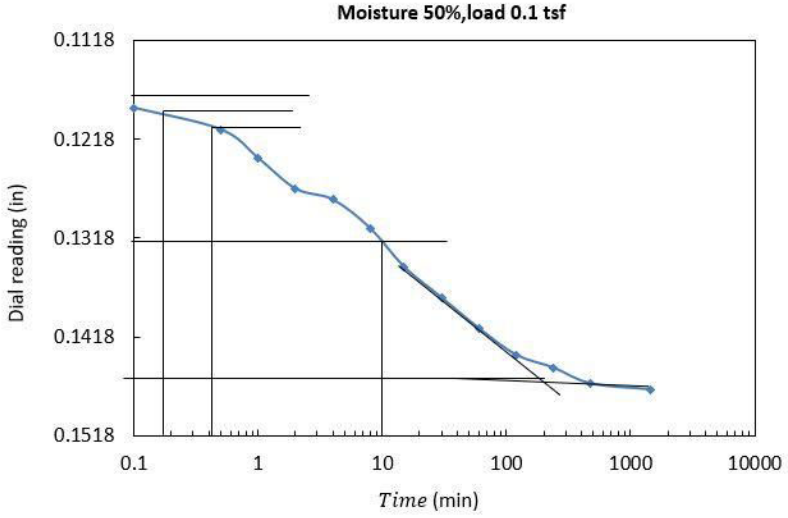


Figure 20. Determination of T_{90} of slurry sample having a moisture content of 50% using conventional oedometer and following Method One


Moisture 50%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.1
1
10
100
1000
10000
Time (min)


Moisture 50%,load 0.025 tsf
Dial reading (in)
0.0878
0.0888
0.0898
0.0908
0.0918
0.0928
0.0938
0.0948
0.0958
0.0968
0.0978
0.1
1
10
100
1000
10000
Time (min)


Moisture 50%,load 0.05 tsf
Dial reading (in)
0.0898
0.0998
0.1098
0.1198
0.1
1
10
100
1000
10000
Time (min)


Moisture 50%,load 0.1 tsf
Dial reading (in)
0.1118
0.1218
0.1318
0.1418
0.1518
0.1
1
10
100
1000
10000
Time (min)

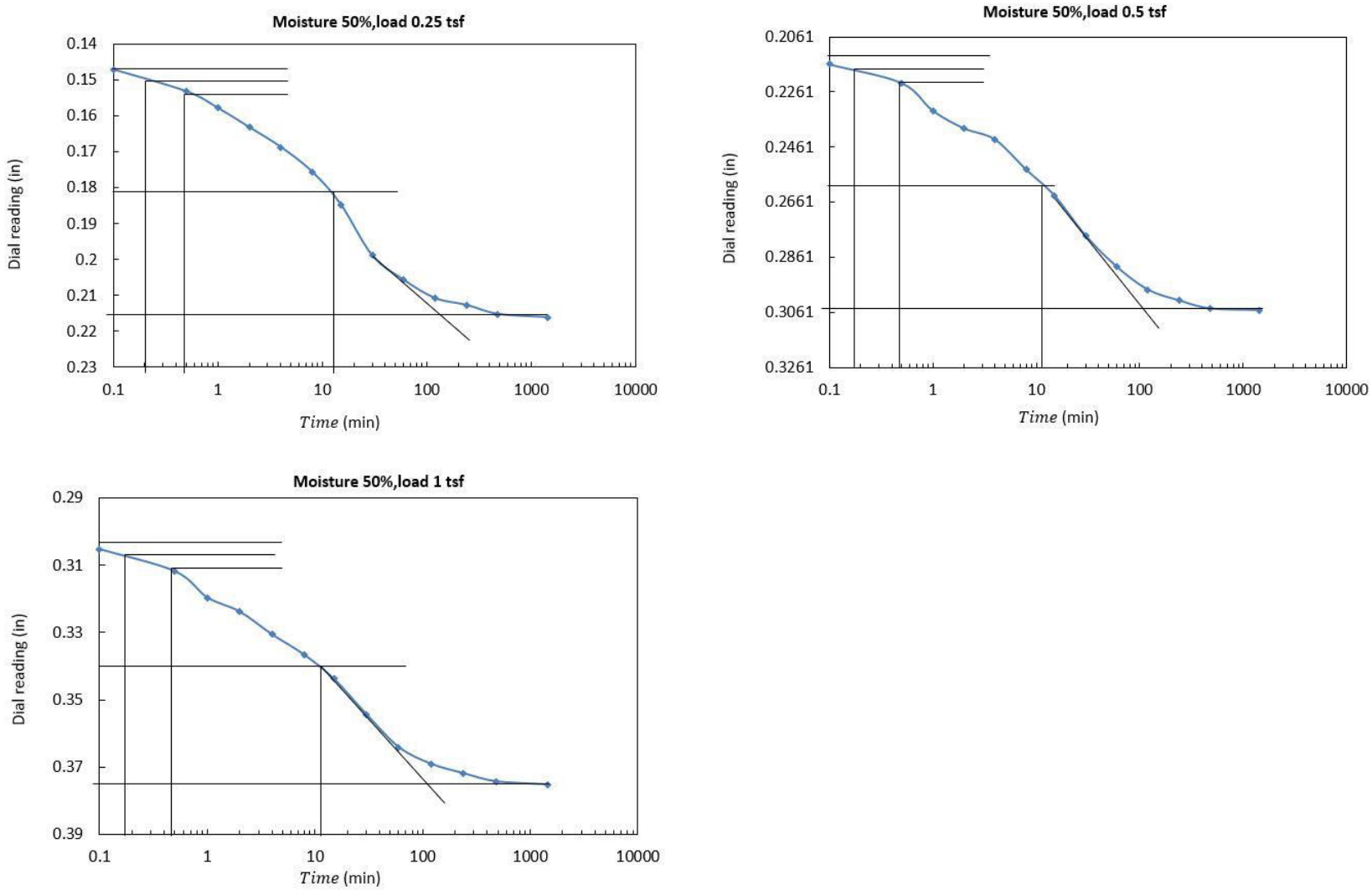


Figure 21. Determination of T_{50} of slurry sample having a moisture content of 50% using conventional oedometer and following Method One

Table 17. Time versus vertical dial readings of slurry sample having a moisture content of 40% using conventional oedometer.

Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.01			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.004	0
0.5	0.707107	0.0172	17.4
1	1	0.0298	34
2	1.414214	0.0398	47.2
4	2	0.0474	57.3
8	2.828427	0.0579	71.1
15	3.872983	0.0689	85.6
30	5.477226	0.0731	91.2
60	7.745967	0.0763	95.4
120	10.95445	0.0782	97.9
240	15.49193	0.0789	98.8
480	21.9089	0.0792	99.2
1440	37.94733	0.0798	100

Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.025			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0798	0
0.5	0.707107	0.0809	15.3
1	1	0.0823	34.7
2	1.414214	0.0836	52.8
4	2	0.0841	59.7
8	2.828427	0.0852	75
15	3.872983	0.0859	84.7
30	5.477226	0.0862	88.9
60	7.745967	0.0866	94.4
120	10.95445	0.0867	95.8
240	15.49193	0.0868	97.2
480	21.9089	0.0869	98.6
1440	37.94733	0.0870	100

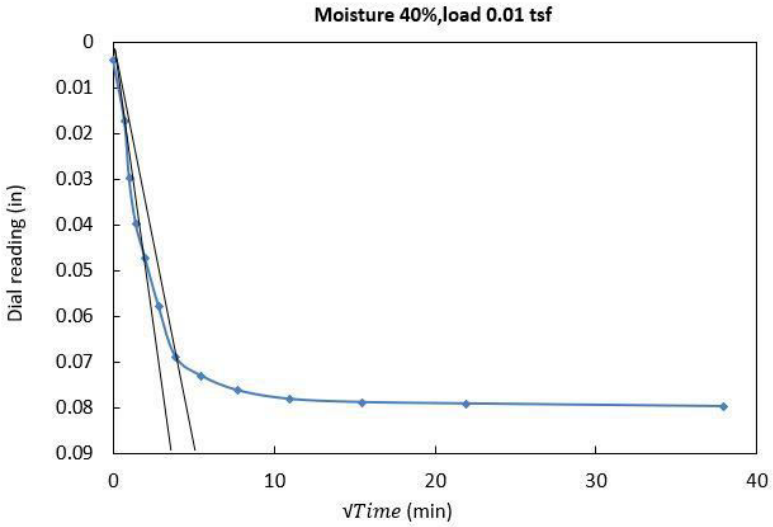
Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.05			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0870	0
0.5	0.707107	0.0889	14.8
1	1	0.0905	27.3
2	1.414214	0.0936	51.6
4	2	0.0949	61.7
8	2.828427	0.0961	71.1
15	3.872983	0.0973	80.5
30	5.477226	0.0984	89.1
60	7.745967	0.0989	93
120	10.95445	0.0992	95.3
240	15.49193	0.0995	97.7
480	21.9089	0.0996	98.4
1440	37.94733	0.0998	100

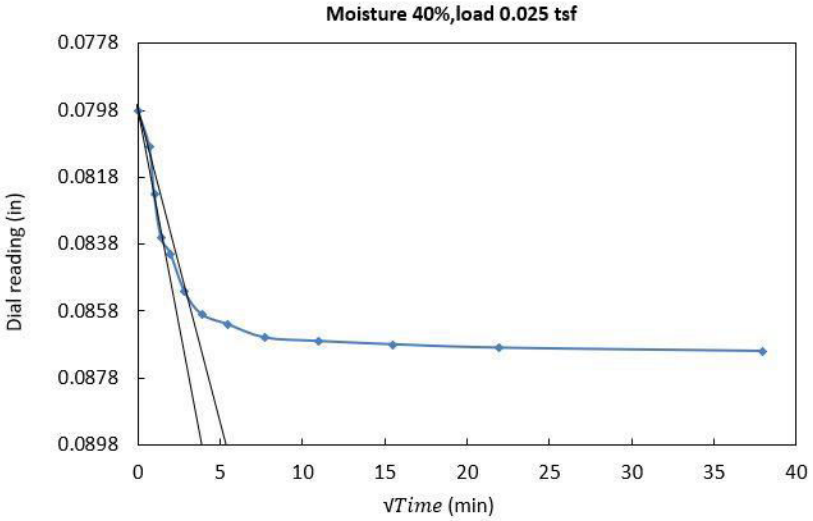
Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.0998	0
0.5	0.707107	0.1017	13.7
1	1	0.1037	28.1
2	1.414214	0.1068	50.4
4	2	0.1079	58.3
8	2.828427	0.1095	69.8
15	3.872983	0.1107	78.4
30	5.477226	0.1118	86.3
60	7.745967	0.1123	89.9
120	10.95445	0.1126	92.1
240	15.49193	0.1129	94.2
480	21.9089	0.1135	98.6
1440	37.94733	0.1137	100

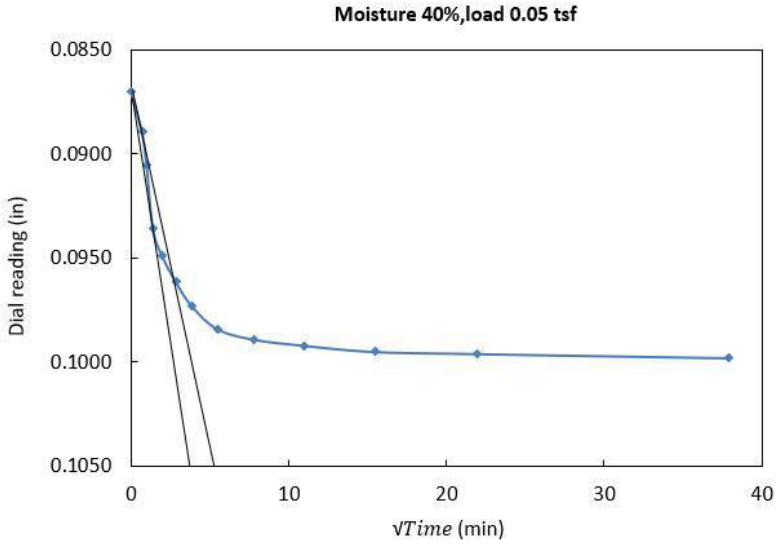
Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.25			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1137	0
0.5	0.707107	0.1192	13.3
1	1	0.1278	34.1
2	1.414214	0.1342	49.5
4	2	0.1387	60.4
8	2.828427	0.1436	72.2
15	3.872983	0.1457	77.3
30	5.477226	0.1489	85
60	7.745967	0.1509	89.9
120	10.95445	0.1518	92
240	15.49193	0.1527	94.2
480	21.9089	0.1542	97.8
1440	37.94733	0.1551	100

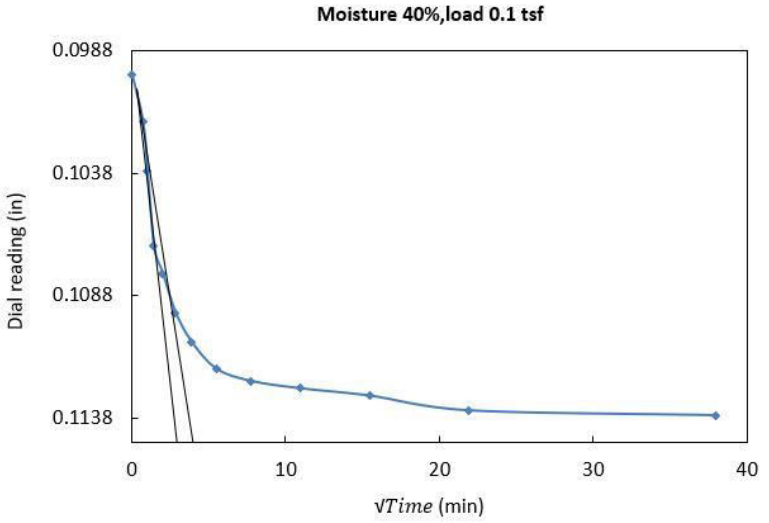
Sample: 40% moisture content			
Pressure on specimen (TSF) = 0.5			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1551	0
0.5	0.707107	0.1603	13.9
1	1	0.1659	28.9
2	1.414214	0.1727	47.1
4	2	0.1779	61
8	2.828427	0.1823	72.7
15	3.872983	0.1849	79.7
30	5.477226	0.1882	88.5
60	7.745967	0.1895	92
120	10.95445	0.1908	95.5
240	15.49193	0.1913	96.8
480	21.9089	0.1921	98.9
1440	37.94733	0.1925	100

Sample: 40% moisture content			
Pressure on specimen (TSF) = 1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0	0	0.1925	0
0.5	0.707107	0.1988	12.7
1	1	0.2068	28.8
2	1.414214	0.2154	46.2
4	2	0.2226	60.7
8	2.828427	0.2267	69
15	3.872983	0.2308	77.2
30	5.477226	0.2353	86.3
60	7.745967	0.2374	90.5
120	10.95445	0.2391	94
240	15.49193	0.2409	97.6
480	21.9089	0.2414	98.6
1440	37.94733	0.2421	100


Moisture 40%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0
10
20
30
40
√Time (min)


Moisture 40%,load 0.025 tsf
Dial reading (in)
0.0778
0.0798
0.0818
0.0838
0.0858
0.0878
0.0898
0
5
10
15
20
25
30
35
40
√Time (min)


Moisture 40%,load 0.05 tsf
Dial reading (in)
0.0850
0.0900
0.0950
0.1000
0.1050
0
10
20
30
40
√Time (min)


Moisture 40%,load 0.1 tsf
Dial reading (in)
0.0988
0.1038
0.1088
0.1138
0
10
20
30
40
√Time (min)

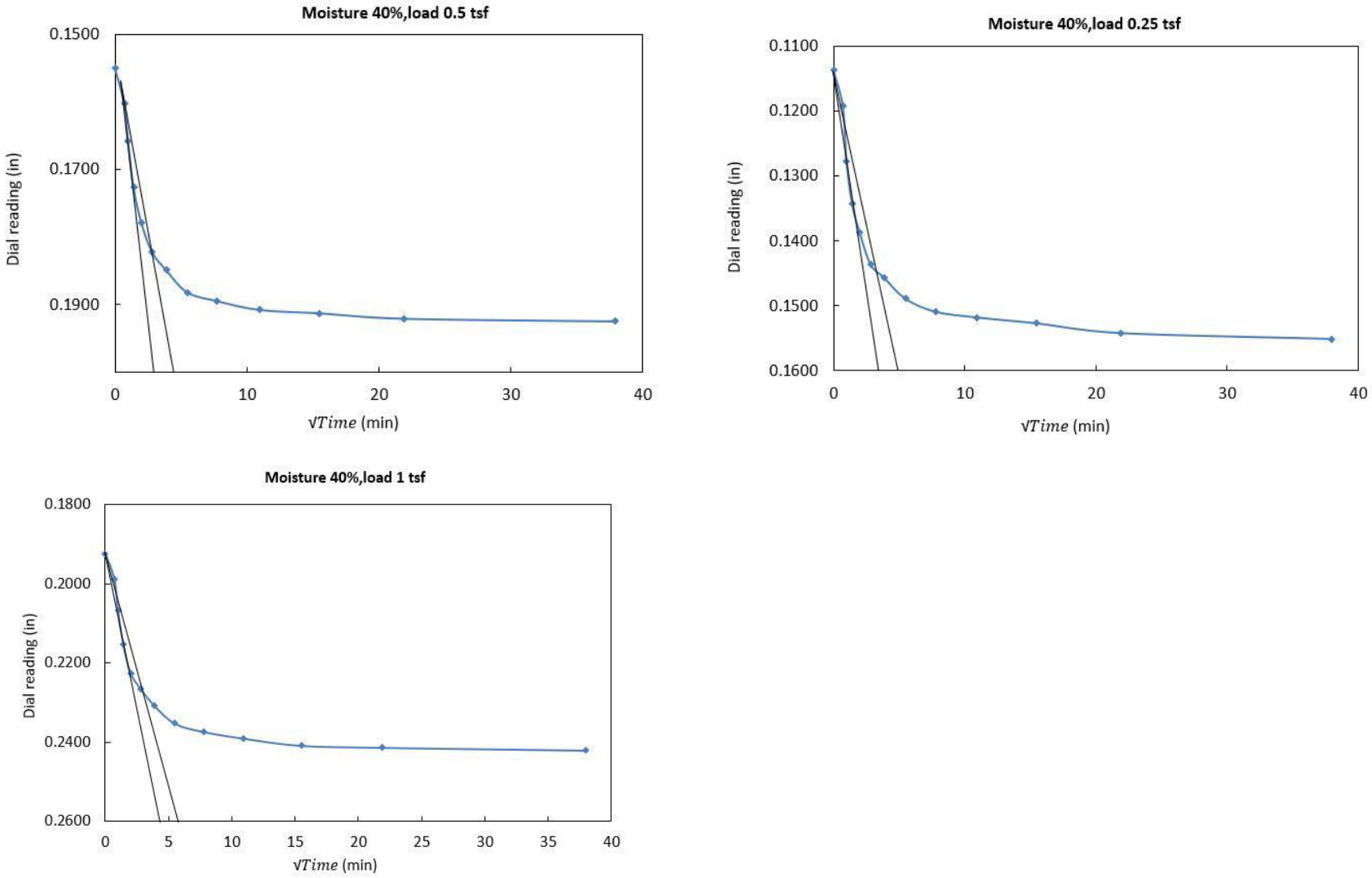
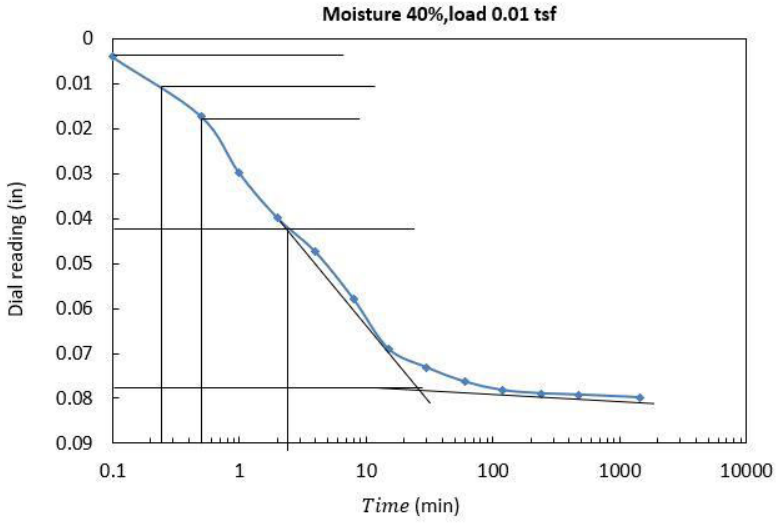
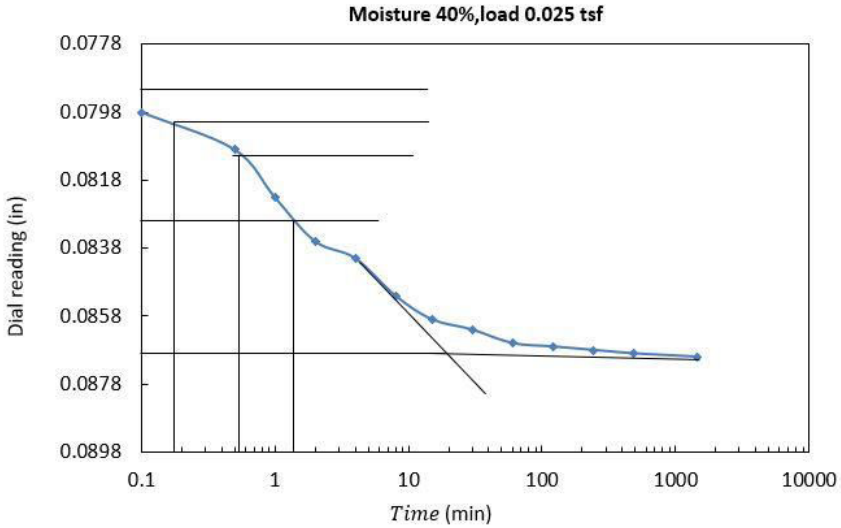
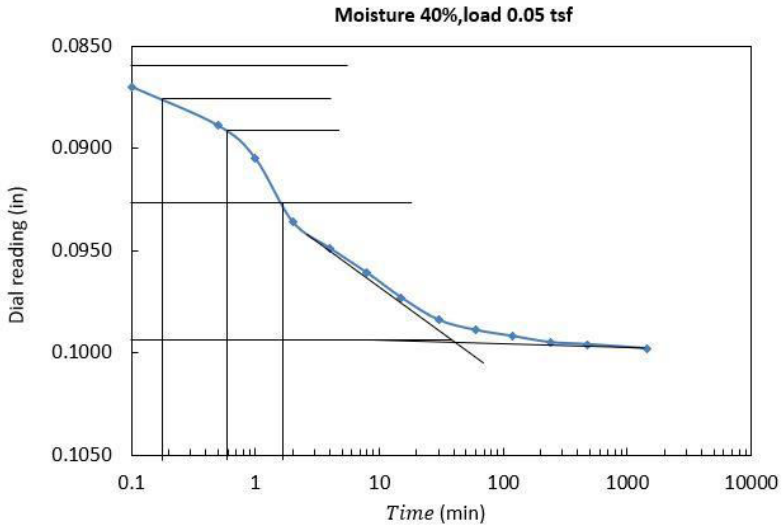
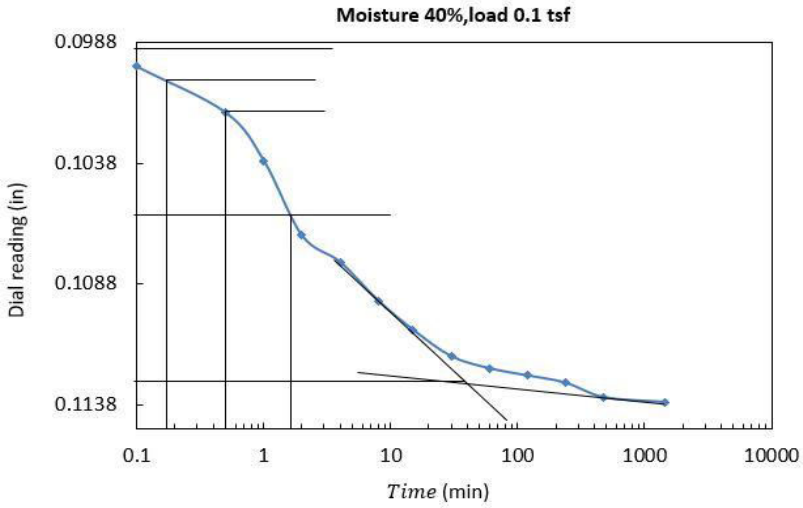


Figure 22. Determination of T_{90} of slurry sample having a moisture content of 40% using conventional oedometer and following Method One


Moisture 40%,load 0.01 tsf
Dial reading (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
1
10
100
1000
10000
Time (min)


Moisture 40%,load 0.025 tsf
Dial reading (in)
0.0778
0.0798
0.0818
0.0838
0.0858
0.0878
0.0898
0.1
1
10
100
1000
10000
Time (min)


Moisture 40%,load 0.05 tsf
Dial reading (in)
0.0850
0.0900
0.0950
0.1000
0.1050
0.1
1
10
100
1000
10000
Time (min)


Moisture 40%,load 0.1 tsf
Dial reading (in)
0.0988
0.1038
0.1088
0.1138
0.1
1
10
100
1000
10000
Time (min)

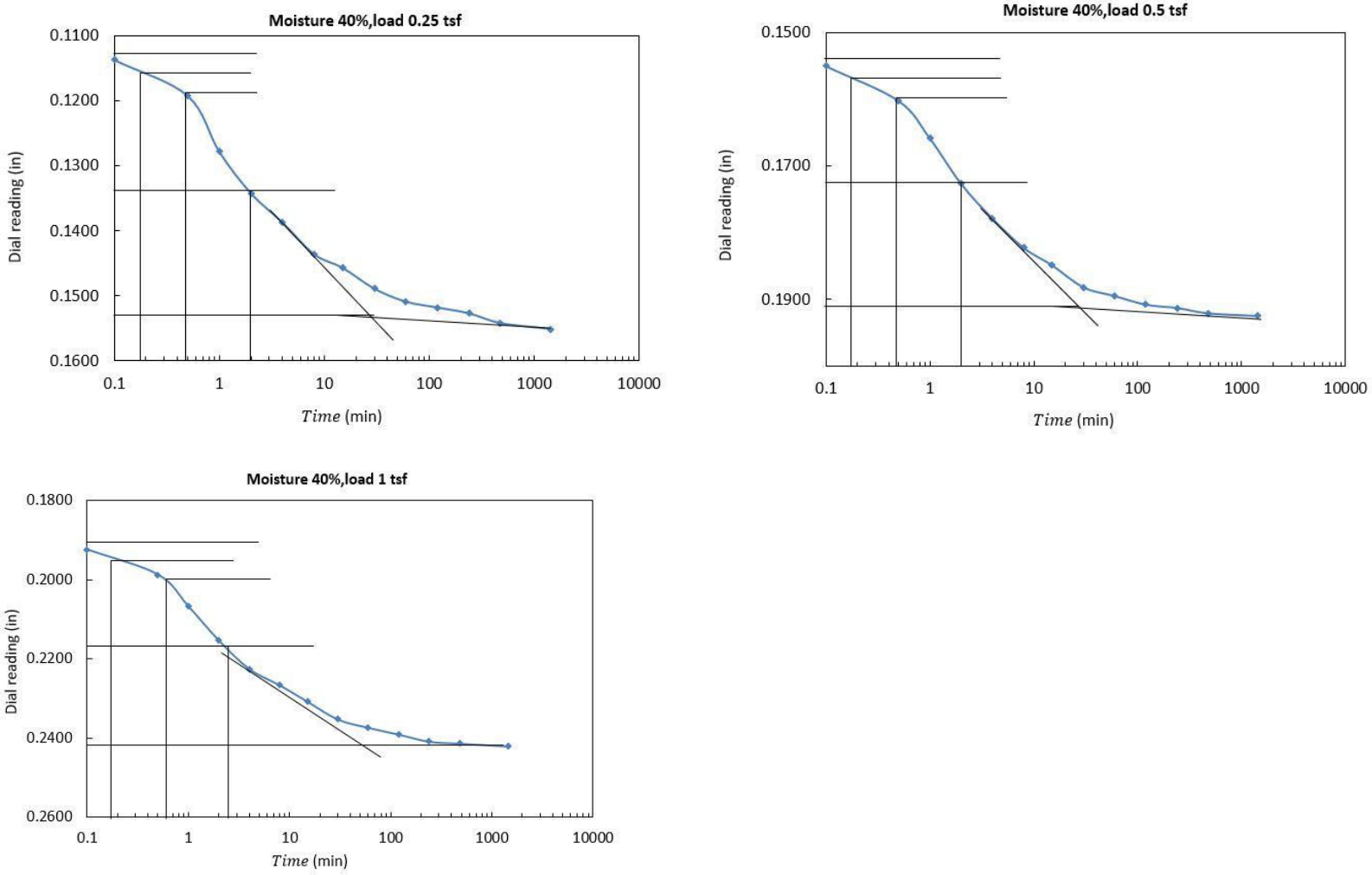


Figure 23. Determination of T_{50} of slurry sample having a moisture content of 40% using conventional oedometer and following Method One

Table 18. Time versus vertical dial readings of slurry sample having a moisture content of 100.1% using conventional oedometer.

Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.002			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.004	0
0.5	0.707107	0.0215	14.2
1	1	0.0412	30.2
2	1.414214	0.0521	39
4	2	0.0681	52
8	2.828427	0.0767	59
15	3.872983	0.0856	66.2
30	5.477226	0.0934	72.6
60	7.745967	0.1004	78.2
120	10.95445	0.1045	81.6
240	15.49193	0.1108	86.7
480	21.9089	0.1126	88.1
1440	37.94733	0.1156	90.6
1680	40.9878	0.1206	94.6
1920	43.8178	0.1216	95.5
2160	46.4758	0.1227	96.3
2400	48.98979	0.1249	98.1
2640	51.38093	0.1269	99.8
2880	53.66563	0.1272	100

Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.005			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.1272	0
0.5	0.707107	0.1288	5.9
1	1	0.1298	9.6
2	1.414214	0.1315	15.8
4	2	0.1337	23.9
8	2.828427	0.1365	34.2
15	3.872983	0.1398	46.3
30	5.477226	0.1413	51.8
60	7.745967	0.1449	65.1
120	10.95445	0.1478	75.7
240	15.49193	0.1503	84.9
480	21.9089	0.1511	87.9
1440	37.94733	0.1519	90.8
1680	40.9878	0.1538	97.8
1920	43.8178	0.1544	100

Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.01			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.1544	0
0.5	0.707107	0.1557	4.6
1	1	0.1567	8.1
2	1.414214	0.1591	16.5
4	2	0.1617	25.6
8	2.828427	0.1654	38.6
15	3.872983	0.1675	46
30	5.477226	0.1698	54
60	7.745967	0.1723	62.8
120	10.95445	0.1756	74.4
240	15.49193	0.1789	86
480	21.9089	0.1809	93
1440	37.94733	0.1825	98.6
1680	40.9878	0.1829	100

Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.025			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.1829	0
0.5	0.707107	0.1867	8.4
1	1	0.1893	14.1
2	1.414214	0.1932	22.7
4	2	0.1986	34.6
8	2.828427	0.2023	42.7
15	3.872983	0.2067	52.4
30	5.477226	0.2112	62.3
60	7.745967	0.2154	71.6
120	10.95445	0.2203	82.4
240	15.49193	0.2225	87.2
480	21.9089	0.2254	93.6
1440	37.94733	0.2277	98.7
1680	40.9878	0.2283	100

Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.05			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.2483	0
0.5	0.707107	0.2484	0.6
1	1	0.2484	0.6
2	1.414214	0.2485	1.3
4	2	0.2487	2.5
8	2.828427	0.2491	5
15	3.872983	0.2493	6.3
30	5.477226	0.2501	11.3
60	7.745967	0.2521	23.9
120	10.95445	0.2549	41.5
240	15.49193	0.2598	72.3
480	21.9089	0.2636	96.2
1440	37.94733	0.2642	100

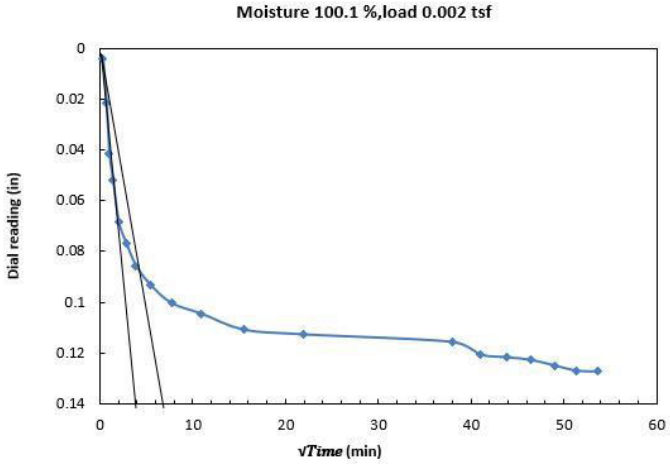
Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.2642	0
0.5	0.707107	0.2649	1.7
1	1	0.2655	3.1
2	1.414214	0.2672	7.1
4	2	0.2694	12.4
8	2.828427	0.2736	22.3
15	3.872983	0.2779	32.5
30	5.477226	0.2842	47.5
60	7.745967	0.2931	68.6
120	10.95445	0.3008	86.9
240	15.49193	0.3038	94.1
480	21.9089	0.3057	98.6
1440	37.94733	0.3063	100

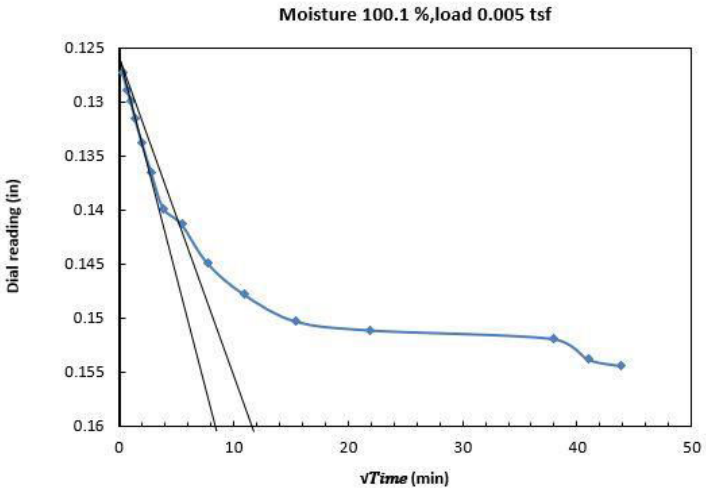
Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.25			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.3063	0
0.5	0.707107	0.3127	9.6
1	1	0.3165	15.2
2	1.414214	0.3278	32.1
4	2	0.3339	41.2
8	2.828427	0.3399	50.1
15	3.872983	0.3437	55.8
30	5.477226	0.3478	61.9
60	7.745967	0.3502	65.5
120	10.95445	0.3565	74.9
240	15.49193	0.3658	88.8
480	21.9089	0.3714	97.2
1440	37.94733	0.3733	100

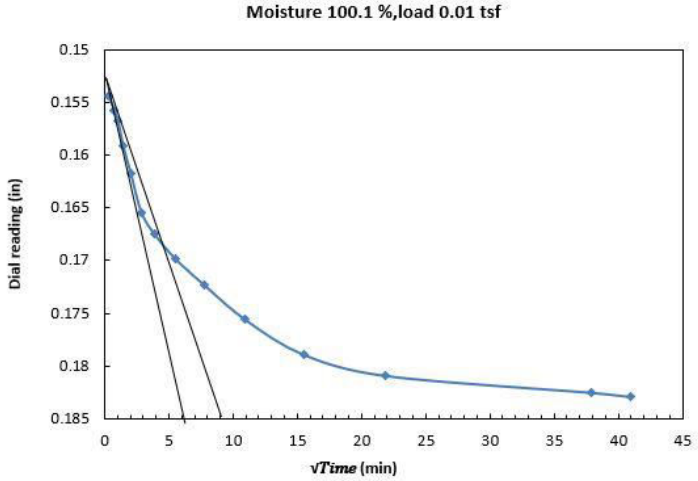
Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 0.5			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.3733	0
0.5	0.707107	0.3754	3.4
1	1	0.378	7.5
2	1.414214	0.3796	10.1
4	2	0.3826	14.9
8	2.828427	0.3874	22.6
15	3.872983	0.3968	37.6
30	5.477226	0.4056	51.7
60	7.745967	0.4159	68.2
120	10.95445	0.4249	82.6
240	15.49193	0.4302	91
480	21.9089	0.4351	98.9
1440	37.94733	0.4358	100

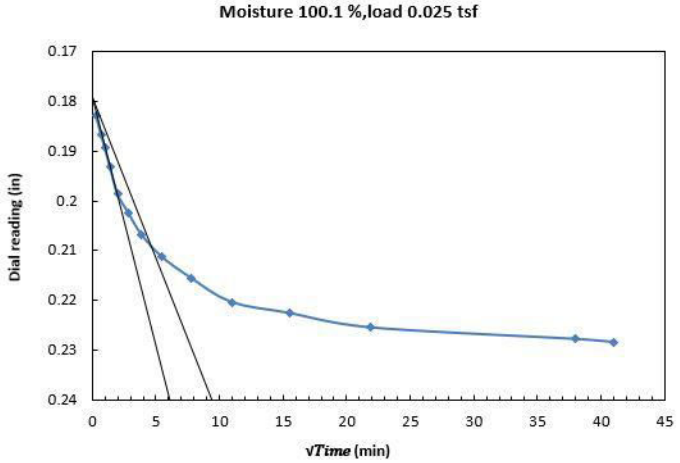
Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 1			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.4358	0
0.5	0.707107	0.4392	7.1
1	1	0.4413	11.4
2	1.414214	0.4431	15.2
4	2	0.4452	19.5
8	2.828427	0.4498	29.1
15	3.872983	0.4594	49.1
30	5.477226	0.4691	69.2
60	7.745967	0.4734	78.2
120	10.95445	0.4768	85.2
240	15.49193	0.4784	88.6
480	21.9089	0.4803	92.5
1440	37.94733	0.4839	100

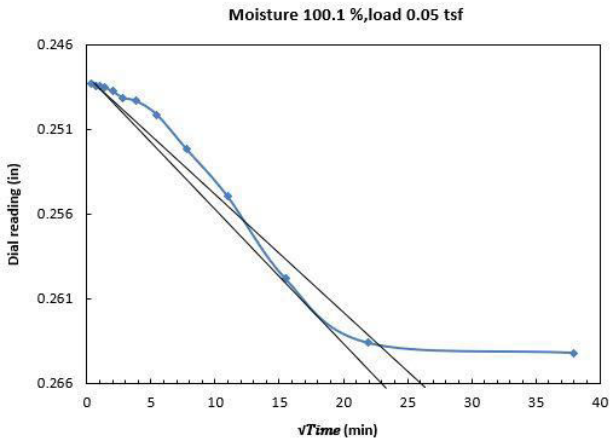
Sample: 100.1 % moisture content			
Pressure on specimen (TSF) = 2			
Time t (min)	Sqrt of t (min)^0.5	vertical dial reading (in)	% Strain change
0.1	0.316228	0.4839	0
0.5	0.707107	0.4878	8
1	1	0.4902	12.9
2	1.414214	0.4959	24.5
4	2	0.5024	37.8
8	2.828427	0.5078	48.8
15	3.872983	0.5129	59.2
30	5.477226	0.5196	72.9
60	7.745967	0.5227	79.2
120	10.95445	0.5254	84.7
240	15.49193	0.5278	89.6
480	21.9089	0.5318	97.8
1440	37.94733	0.5329	100

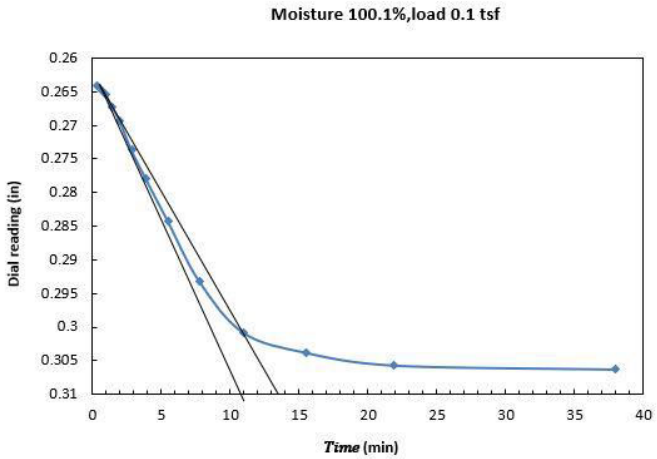

Moisture 100.1 %,load 0.002 tsf
Dial reading (in)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0
10
20
30
40
50
60
√Time (min)

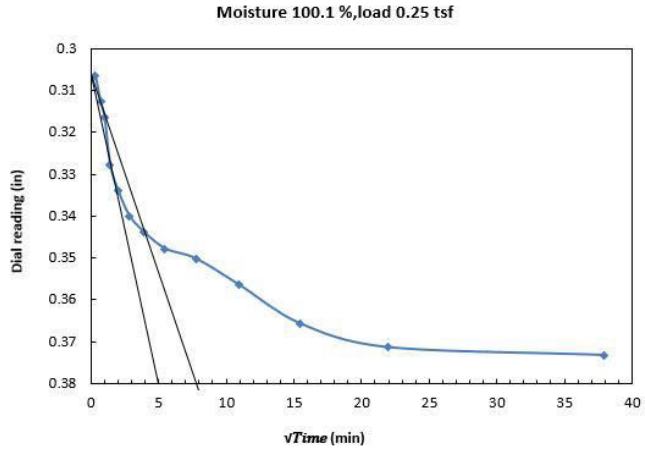

Moisture 100.1 %,load 0.005 tsf
Dial reading (in)
0.125
0.13
0.135
0.14
0.145
0.15
0.155
0.16
0
10
20
30
40
50
√Time (min)

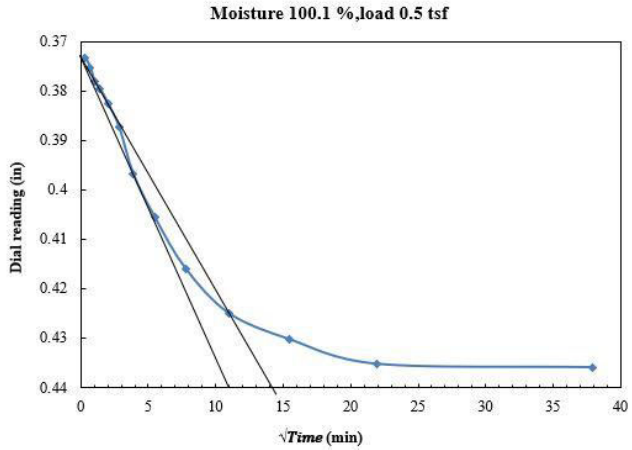

Moisture 100.1 %,load 0.01 tsf
Dial reading (in)
0.15
0.155
0.16
0.165
0.17
0.175
0.18
0.185
0
5
10
15
20
25
30
35
40
45
√Time (min)


Moisture 100.1 %,load 0.025 tsf
Dial reading (in)
0.17
0.18
0.19
0.2
0.21
0.22
0.23
0.24
0
5
10
15
20
25
30
35
40
45
√Time (min)


Moisture 100.1 %,load 0.05 tsf
Dial reading (in)
0.246
0.251
0.256
0.261
0.266
0 5 10 15 20 25 30 35 40
√Time (min)


Moisture 100.1%,load 0.1 tsf
Dial reading (in)
0.26
0.265
0.27
0.275
0.28
0.285
0.29
0.295
0.3
0.305
0.31
0 5 10 15 20 25 30 35 40
Time (min)


Moisture 100.1 %,load 0.25 tsf
Dial reading (in)
0.3
0.31
0.32
0.33
0.34
0.35
0.36
0.37
0.38
0 5 10 15 20 25 30 35 40
√Time (min)


Moisture 100.1 %,load 0.5 tsf
Dial reading (in)
0.37
0.38
0.39
0.4
0.41
0.42
0.43
0.44
0 5 10 15 20 25 30 35 40
√Time (min)

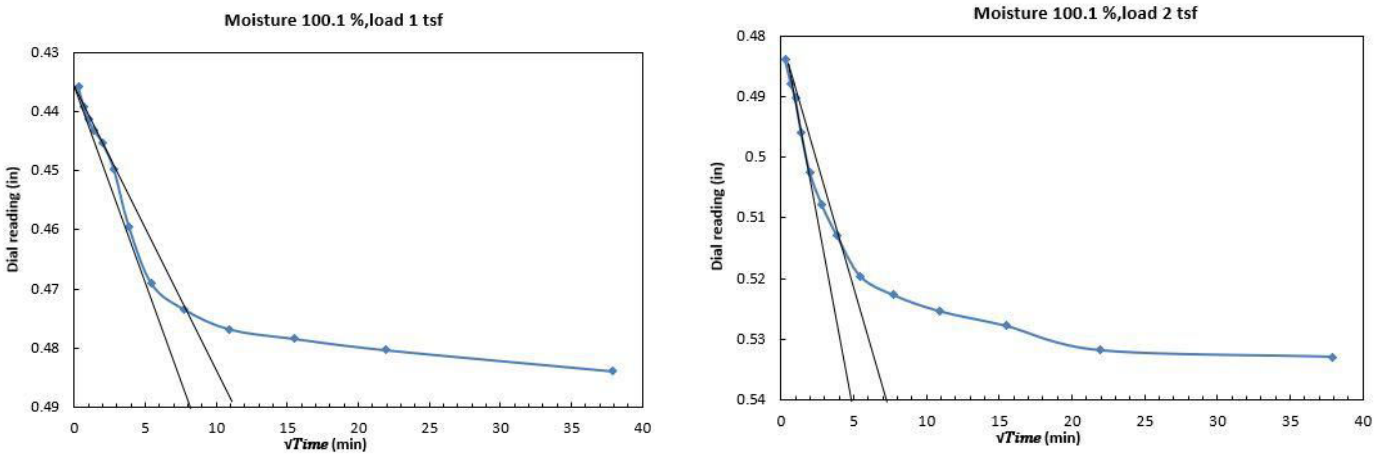
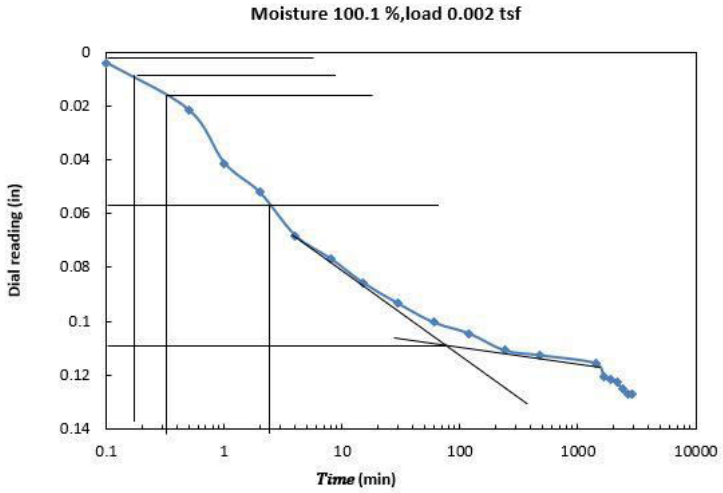
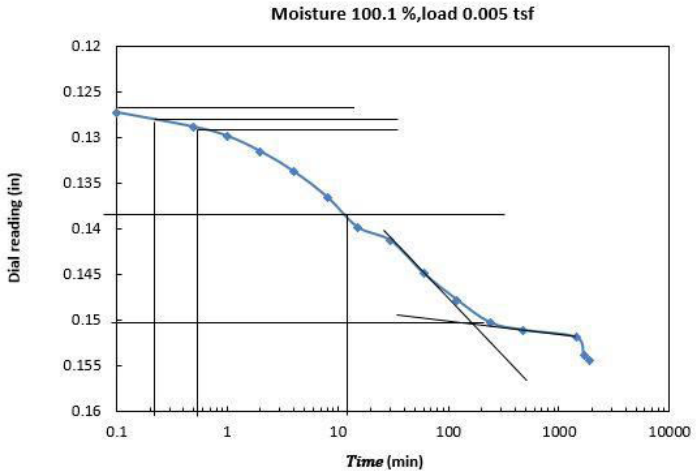
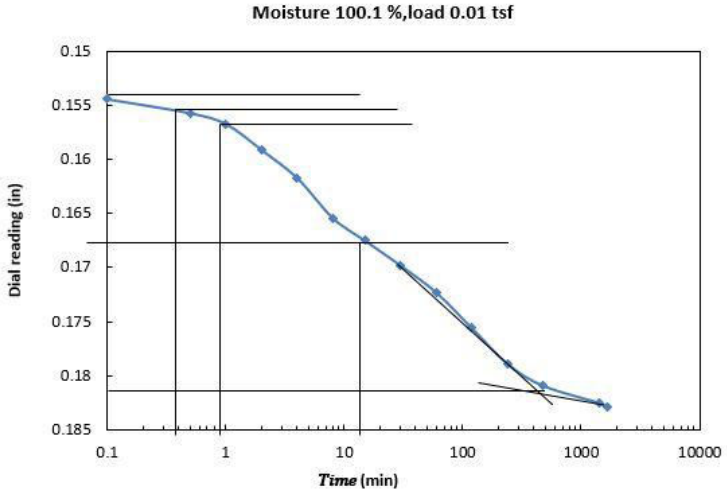
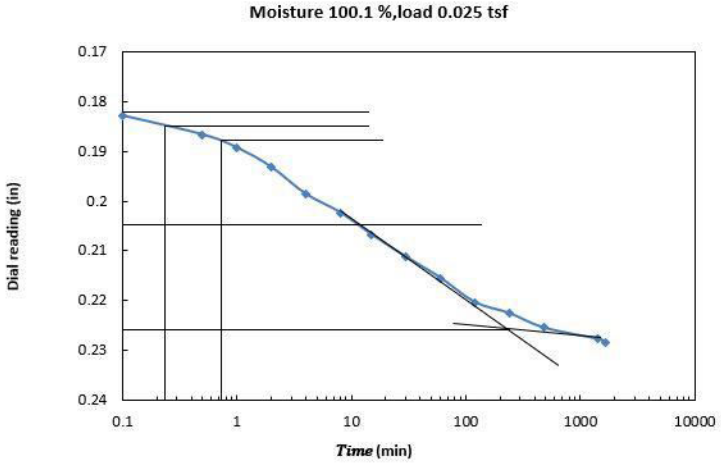


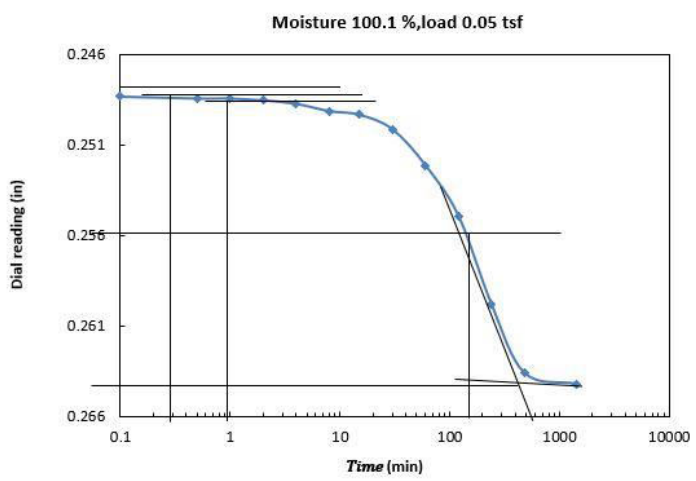
Figure 24. Determination of T_{90} of slurry sample having a moisture content of 100.1% using modified oedometer and following Method Two

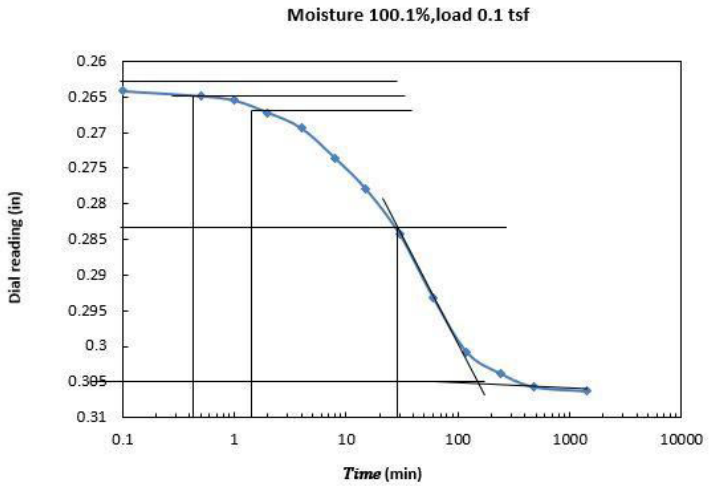

Moisture 100.1 %,load 0.002 tsf
Dial reading (in)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.1
1
10
100
1000
10000
Time (min)

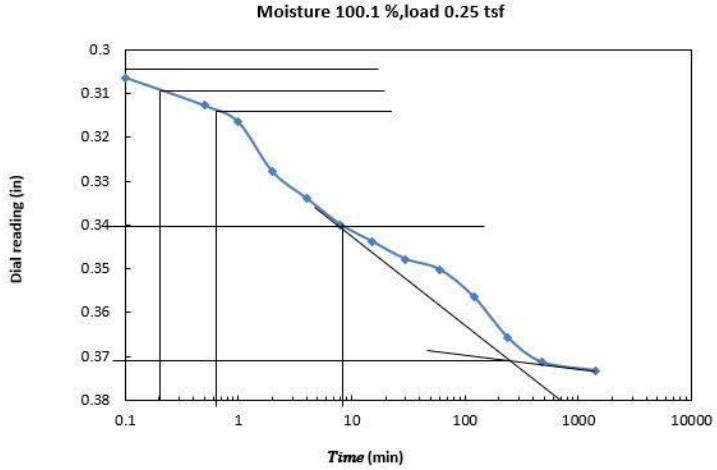

Moisture 100.1 %,load 0.005 tsf
Dial reading (in)
0.12
0.125
0.13
0.135
0.14
0.145
0.15
0.155
0.16
0.1
1
10
100
1000
10000
Time (min)

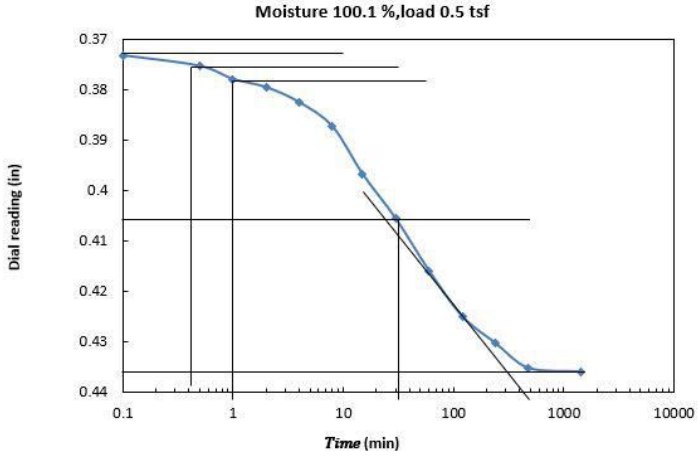

Moisture 100.1 %,load 0.01 tsf
Dial reading (in)
0.15
0.155
0.16
0.165
0.17
0.175
0.18
0.185
0.1
1
10
100
1000
10000
Time (min)


Moisture 100.1 %,load 0.025 tsf
Dial reading (in)
0.17
0.18
0.19
0.2
0.21
0.22
0.23
0.24
0.1
1
10
100
1000
10000
Time (min)


Moisture 100.1 %,load 0.05 tsf
Dial reading (in)
0.246
0.251
0.256
0.261
0.266
0.1
1
10
100
1000
10000
Time (min)


Moisture 100.1%,load 0.1 tsf
Dial reading (in)
0.26
0.265
0.27
0.275
0.28
0.285
0.29
0.295
0.3
0.305
0.31
0.1
1
10
100
1000
10000
Time (min)


Moisture 100.1 %,load 0.25 tsf
Dial reading (in)
0.3
0.31
0.32
0.33
0.34
0.35
0.36
0.37
0.38
0.1
1
10
100
1000
10000
Time (min)


Moisture 100.1 %,load 0.5 tsf
Dial reading (in)
0.37
0.38
0.39
0.4
0.41
0.42
0.43
0.44
0.1
1
10
100
1000
10000
Time (min)

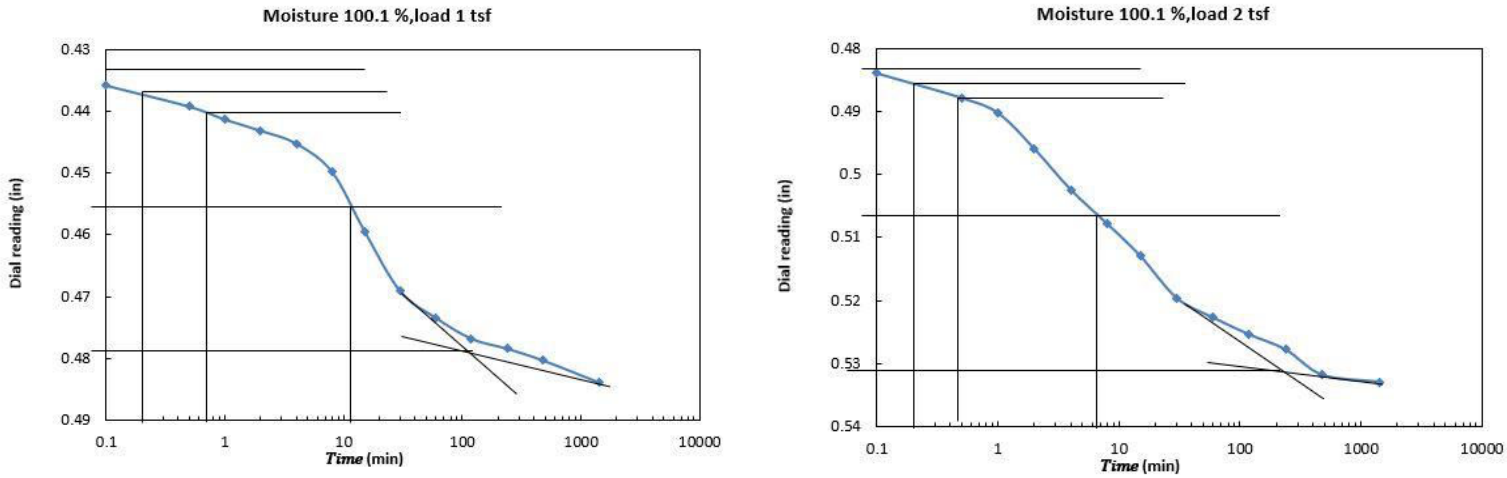


Figure 25. Determination of T_{50} of slurry sample having a moisture content of 100.1% using modified oedometer and following Method Two